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Proceedings of the Lake Superior Mining Institute

Lake Superior Mining Institute

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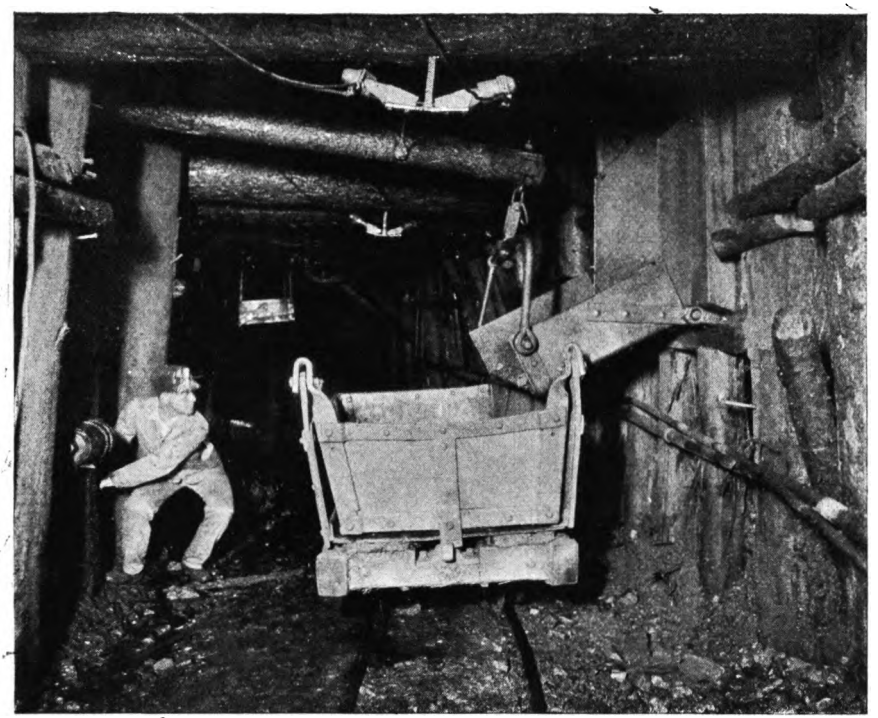
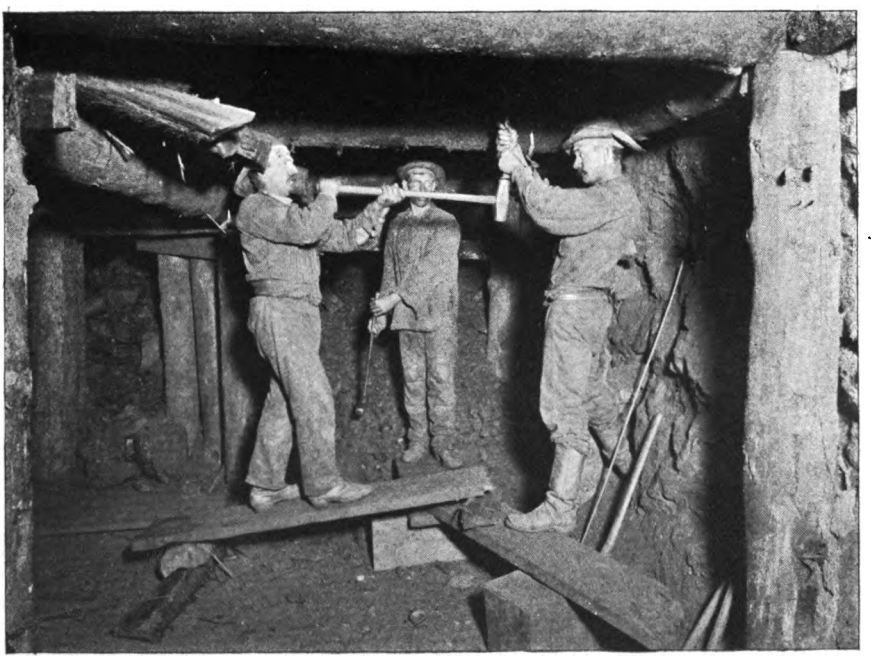


View in the Main Drift, 9th Level, M. I. Co., Soudan, Minn., Showing Arrangements for Loading Ore into Cars.



View in Workings at the Top of a Raise in the East-End Mine, P. & L. A. Co., Ishpeming, Mich. The miners are preparing to cave ore left in the back of a drift.

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PROCEEDINGS

OF THE

LAKE SUPERIOR MINING INSTITUTE

FOURTH ANNUAL MEETING

AUGUST, 1896

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LAKE SUPERIOR MINING INSTITUTE, 1896.

PRESIDENT.

	Term expires August
WM. G. MATHER,	1897

VICE-PRESIDENTS.

F. MCM. STANTON,	1897
GEO. A. NEWETT,	1897
PER LARSSON,	1897
GEO. H. ABEEL,	1898
JOHN F. ARMSTRONG,	1898

MANAGERS.

F. P. MILLS,	1897
EDWIN BALL,	1897
GRAHAM POPE,	1898
WM. KELLY,	1898
C. H. MUNGER,	1898

TREASURER.

GEO. D. SWIFT,	1897

SECRETARY.

F. W. DENTON,	1897

(The above officers constitute the council.)

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HONORARY MEMBERS.

Raphael Pumpelly. T. B. Brooks. N. H. Winchell.

ACTIVE MEMBERS.

Alvar, G. A., Commonwealth, Wis.
Abeel, Geo. H., Hurley, Wis.
Adams, John Q., Negaunee, Mich.
Anderson, W. H., 1214 N. 3rd St., Ishpeming, Mich.
Appleby, Wm. R., Minneapolis, Minn.
Armstrong, J. F., St. Louis Hotel, Duluth, Minn.
Ball, Edwin, Soudan, St. Louis Co., Minn.
Bacon, D. H., Soudan, St. Louis Co., Minn.
Bailey, C. E., Virginia, Minn.
Baker, Fred J., Ishpeming, Mich.
Barker, John, Iron Mountain, Mich.
Barnett, James H.
Bayley, W. S., Waterville, Me.
Beattie, S. T., Florence, Wis.
Bennett, R. M., Minneapolis, Minn.
Bokman, Chas. E., Iron Mountain, Mich.
Bond, William, Vulcan, Mich.
Boss, C. M., Virginia, Minn.
Brady, Samuel, Detroit, Mich.
Braastad, Frederick, Ishpeming, Mich.
Breitung, Edward N., Marquette, Mich.
Brown, E. F., Iron Mountain, Mich.
Brown, Wm. C., Box 14, Brooklyn, N. Y.
Bullock, M. C., Chicago, Ill.
Burt, M. W., Ely, Minn
Burt, Hiram, Marquette, Mich.
Butler, W. C., Everett, Wash.
Bradt, E. F., Ishpeming, Mich.
Brett, Henry, Calumet, Mich.
Chynoweth, B. F., Calumet, Mich.
Chadbourne, T. L., Houghton, Mich.
Channing, J. Parke, 34 Park Place, New York City.
Chipman, J. C. W., Ishpeming, Mich.
Clancy, James, Ishpeming, Mich.
Cohoe, J. G., Virginia, Minn.
Cole, T. F., Negaunee, Mich.
Collick, Alfred, Ishpeming, Mich.
Conro, Albert, Milwaukee, Wis.
Cooper, James B., South Lake Linden, Mich.
Copeland, F., Vulcan, Mich.
Coventry, F. L., Commonwealth, Wis.
Crowell, Benedict, Cleveland, O.
Croze, W. W. J., Denver, Col.
Channing, R. H., Jr., Eveleth, Minn.
Curry, S. S., Ironwood, Mich.
Davidson, O. C., Commonwealth, Wis.
Denton, F. W., Minneapolis, Minn.
Dee, James R., Houghton, Mich.
Dickinson, Wm. E., Florence, Wis.
Dubois, Howard, W., 1527 N. 20th St., Philadelphia, Pa.
Duncan, John, Calumet, Mich.
Duncan, Murray M., Ishpeming, Mich.
Dunham, L. E., Ashland, Wis.
Dunn, W. A., Houghton, Mich.
Dyer, H., Globe, Arizona.
Dengler, Theo., Denver, Col.
Ellard, H. F., Commonwealth, Wis.
Edwards, A. D., Atlantic Mine, Mich.
Elliot, Mark, Palmer, Mich.
Emmerton, F. A., Cleveland, O.
Ericson, Rudolph, Ishpeming, Mich.

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Esselstyn, John W., Ishpeming, Mich.
Fairbairn, C. T., Ishpeming, Mich.
Fisher, James, Hancock, Mich.
Fitch, Walter, Beacon, Mich.
Farrel, Austin, Marquette, Mich.
Frankforter, G. B., Minneapolis, Minn.
Findley, A. I., 27 Vincent Street, Cleveland, O.
Goudie, Jas. H., Ironwood, Mich.
Gibbs, Geo., Milwaukee, Wis.
Gibson, Matthew, Champion, Mich.
Gibson, Thoburn, Amasa, Mich.
Gilchrist, J. D., Mountain Iron, Minn.
Gill, William, Orconera Iron Ore Co., Bilbao, Spain.
Green, R. B., Two Harbors, Minn.
Goldsworthy, Martin, Iron Mountain, Mich.
Goodsell, B. W., 20 W. Lake St., Chicago, Ill.
Gordon, T. S., 171 Lake St., Chicago, Ill.
Grant, U. S., Minneapolis, Minn.
Greenwood, George.
Hall, C. W., Minneapolis, Minn.
Hall, C. H., Ishpeming, Mich.
Hanna, L. C., Cleveland, O.
Harris, John L., Hancock, Mich.
Harris, S. B., Hancock, Mich.
Hauserman, Jacob, Commonwealth, Wis.
Hearding, J. H., Virginia, Minn.
Heath, Geo. L., South Lake Linden, Mich.
Hodge, Chas. J., Houghton, Mich.
Hendrick, C. E., Ishpeming, Mich.
Hellberg, Gustaf A., Norway, Mich.
Hocking, T. H., Hurley, Wis.
Holland, James, Iron Mountain, Mich.
Holley, S. H., Marquette, Mich.
Honnold, W. L., California Exploration Co., San Andreas, Calaveras Co., Cal.
Hooper, J. K., Crystal Falls, Mich.
Hopkins, E. W., Commonwealth, Wis.
Houghton, Jacob, 51 E. Elizabeth St., Detroit, Mich.
Hubbard, Lucius L., Houghton, Mich.
Hughes, C. W., Amasa, Mich.
Hulst, Nelson P., Milwaukee, Wis.
Hotson, W. E., Florence, Wis.
Johnston, Wm. H., Ishpeming, Mich.
Jones, J. T., Iron Mountain, Mich.
Jopling, A. O., Marquette, Mich.
Jopling, James E., Ishpeming, Mich.
Judson, F. A., Trenton, N. J.
Karkeet, J. H., Iron Mountain, Mich.
Kaufman, Louis G., Marquette, Mich.
Kelly, William, Vulcan, Mich.
Kidwell, Edgar, Houghton, Mich.
Kirkpatrick, Clark, Palmer, Mich.
Knight, R. C., Commonwealth, Wis.
Knight, J. B., Norway, Mich.
Koenig, Geo. A., Houghton, Mich.
Kruse, Chas. T., Ishpeming, Mich.
LaLonde, B. E., Ishpeming, Mich.
Lane, Alfred C., Houghton, Mich.
Lane, J. S., Box 131, Westport, Conn.
Larsson, Per, Norway, Mich.
Lawrence, Chas. E., Amasa, Mich.
Lerch, Fred, Virginia, Minn.
Longyear, J. M., Marquette, Mich.
Lyon, J. B., Norway, Mich.
Lutey, John T., Ishpeming, Mich.
Luxmore, T. L., Iron Mountain, Mich.
Mason, Clarence G., Negaunee, Mich.
Mather, Wm. G., Cleveland, O.
McDonald, E. H., Deer Lodge, Mont.
McGee, M. B., Crystal Falls, Mich.
McLean, John H., Iron Mountain, Mich.
McNaughton, James, Iron Mountain, Mich.
McVichie, Duncan, Iron Belt, Wis.
Merton, James M., Calumet, Mich.
Miller, L. B., 39 Wade Building, Cleveland, O.
Mills, F. P., Denver, Col.
Mixer, Charles T., Ishpeming, Mich.
Morgan, D. T., Republic, Mich.
Munger, C. H., Ironwood, Mich.
Munroe, H. S., School of Mines, New York, N. Y.
McNamara, T., Ishpeming, Mich.
Newett, Geo. A., Ishpeming, Mich.
O'Brien, W. H., Rooms 24-25, 122 LaSalle St., Chicago, Ill.
Olcott, W. J., Duluth, Minn.
O'Neil, D. T.
Orrison, J., Iron Mountain, Mich.

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Osborn, C. S., Sault Ste. Marie, Mich.
Palmer, E. V., Negaunee, Mich.
Parker, Richard A., Cal. Exploration Co., San Francisco, Cal.
Paull, H. B., 615 Lyceum Building, Duluth, Minn.
Parnall, S. A., Globe, Arizona.
Parnall, Wm. E., Calumet, Mich.
Parker, Wm. A., 1515 Old Colony Building, Chicago, Ill.
Pascoe, Peter W., Republic, Mich.
Pearse, Frank E., Marquette, Mich.
Pengilly, John, Ely, Minn.
Perkins, R. D.
Pitkin, S. H., Akron, O.
Philbin, D. M., Duluth, Minn.
Pope, Graham, Houghton, Mich.
Prescott, F. M , Oregon St., Milwaukee, Wis.
Quinn, John H., Ishpeming, Mich.
Rattle, W. J., 807 Western Reserve Building, Cleveland, O.
Redfern, J. A., Hibbing, Minn.
Roberts, E. J., Mastodon, Mich.
Robinson, A. W., So. Milwaukee, Wis.
Rothwell, R. P., 519 Broadway, New York, N. Y.
Rough, James H., Negaunee, Mich.
Ryan, Edward, Hancock, Mich.
Rose, R. S., Marquette, Mich.
Rothwell, H. G., Vulcan, Mich.
Seaman, E. A., Houghton, Mich.
Scadden, Frank, Crystal Falls, Mich.
Scott, Dunbar D., Iron Belt, Wis.
Sharpless, F. F., Wright Block, Minneapolis, Minn.
Shaw, Quincy A., 12 Ashburton Place, Boston, Mass.
Simpson, C. S., Florence, Wis.
Sjorgren, S. A. Hjalmar, Upsala, Sweden.
Smith, Wm. W., Hurley, Wis.
Snider, S. P., Minneapolis, Minn.
Sperr, F. W., Houghton, Mich.
Stabler, O. F., Ironwood, Mich.
Stackhouse, Powell, Hotel Lorraine, Philadelphia, Pa.
Stanton, F. McM., Atlantic Mine, Mich.
Stanton, John, 11 and 13 William St., New York.
Storey, Jos., Ishpeming, Mich.
Sullivan, Dan. E., Hurley, Wis.
Suess, Jos. E., Negaunee, Mich.
Sutton, L. B., Iron Mountain, Mich.
Swift, Geo. D., Duluth, Minn.
Trebilcock, Wm., Ironwood, Mich.
Trevarthan, G. C., Florence, Wis.
Van Dyke, Wm. D., Milwaukee, Wis.
Van Dyke, John H., care Pewabic Co., Milwaukee, Wis.
Van Hise, C. R., Madison, Wis.
Van Mater, J. A., Franklin Furnace, N. J.
Vickers, J. M., Ishpeming, Mich.
Wadsworth, M. E., Houghton, Mich.
Wallace, John, 403 E. Michigan St., Marquette, Mich.
Wallace, Geo. W., Virginia, Minn.
Wenstrom, Olof, Sulitjelma, Norway.
White, Peter, Marquette, Mich.
Whiting, S. B., Calumet, Mich.
Wilkinson, C. D., 520 Lumber Exchange, Minneapolis, Minn.
Williams, W. H., 218 Bluff St., Marquette, Mich.
Winchell, Horace V., Minneapolis, Minn.
Yungbluth, A. J., Ishpeming, Mich.

DECEASED MEMBERS.

J. D. Whitney. Francis Hinton.

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RULES OF THE INSTITUTE.

I.

OBJECTS.

The objects of the Lake Superior Mining Institute are, to promote the arts and sciences connected with the economical production of the useful minerals and metals in the Lake Superior region, and the welfare of those employed in these industries, by means of meetings for social intercourse, by excursions, and by the reading and discussion of practical and professional papers, and to circulate, by means of publications among its members, the information thus obtained.

II.

MEMBERSHIP.

Any person interested in the objects of the Institute is eligible for membership.

Honorary members, not exceeding ten in number, may be admitted to all the privileges of regular members except to vote. They must be persons eminent in mining or sciences relating thereto.

III.

ELECTION OF MEMBERS.

Each person desirous of becoming a member shall be proposed by at least three members, approved by the council, and elected by ballot at a regular meeting (or by ballot at any time conducted through the mail, as the council may prescribe) upon receiving three-fourths of the votes cast. He shall become a member on the payment of his first annual dues, within ninety days of the notification of his election.

Each person proposed as an honorary member shall be recommended by at least ten members, approved by the council, and elected by ballot at a regular meeting (or by ballot at any time conducted through the mail, as the council may prescribe), on receiving nine-tenths of the votes cast.

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IV.

WITHDRAWAL FROM MEMBERSHIP.

Upon the recommendation of the council, any member may be stricken from the list and denied the privilege of membership, by the vote of three-fourths of the members present at any regular meeting, due notice having been mailed in writing by the secretary to him.

V.

DUES.

The dues of members shall be five dollars, payable upon their election, and five dollars per annum thereafter, payable in advance at or before the annual meeting. Honorary members shall not be liable to dues. Any member not in arrears may become a life member by the payment of fifty dollars at one time, and shall not be liable thereafter to annual dues. Any member in arrears may, at the discretion of the council, be deprived of the receipt of publications or be stricken from the list of members when in arrears six months; PROVIDED, that he may be restored to membership by the council on the payment of all arrears, or by reelection after an interval of three years.

VI.

OFFICERS.

There shall be a president, five vice-presidents, five managers, a secretary and a treasurer, and these officers shall constitute the council.

VII.

TERM OF OFFICE.

The president, secretary and treasurer shall be elected for one year and the vice-presidents and managers for two years, except that at the first election two vice-presidents and three managers shall be elected for only one year. No president, vice-president or manager shall be eligible for immediate reelection to the same office at the expiration of the term for which he was elected. The term of office shall continue until the adjournment of the meeting at which their successors are elected.

Vacancies in the council, whether by death, resignation, or the failure for one year to attend the council meetings, or to perform the duties of the office, shall be filled by the appointment of the council, and any person so appointed shall hold office for the remainder of the term for which his predecessor was elected or appointed; PROVIDED, that such appointment shall not render him ineligible at the next election.

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VIII.

DUTIES OF OFFICERS.

All the affairs of the Institute shall be managed by the council, except the selection of the place of holding regular meetings.

The duties of all officers shall be such as usually pertain to their offices, or may be delegated to them by the council.

The council may in its discretion require bonds to be given by the treasurer, and may allow the secretary such compensation for his services as they deem proper.

At each annual meeting the council shall make a report of proceedings to the Institute, together with a financial statement.

Five members of the council shall constitute a quorum; but the council may appoint an executive committee, or business may be transacted at a regularly called meeting of the council, at which less than a quorum is present, subject to the approval of a majority of the council, subsequently given in writing to the secretary and recorded by him with the minutes.

There shall be a meeting of the council at every regular meeting of the Institute and at such other times as they determine.

IX.

ELECTION OF OFFICERS.

Any five members, not in arrears, may nominate and present to the secretary over their signatures, at least thirty days before the annual meeting, the names of such candidates as they may select for offices falling under the rules. The council, or a committee thereof duly authorized for the purpose, may also make similar nominations. The assent of the nominees shall have been secured in all cases.

Not less than two weeks prior to the annual meeting, the secretary shall mail to all members not in arrears a list of all nominations made, and the number of officers to be voted for in the form of a letter ballot. Each member may vote either by striking from or adding to the names upon the list, leaving names not exceeding in number the officers to be elected, or by preparing a new list, signing the ballot with his name, and either mailing it to the secretary, or presenting it in person at the annual meeting.

In case nominations are not made thirty days prior to the date of the annual meeting for all the offices becoming vacant under the rules, nominations for such offices may be made at the said meeting by five members not in arrears, and an election held by a written or printed ballot.

The ballots in either case shall be received and examined by three tellers appointed at the annual meeting by the presiding officer; and the persons who shall have received the greatest number of votes for the several offices shall be declared elected. The ballots shall be destroyed, and a list of the elected officers, certified by the tellers, shall be preserved by the secretary.

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X.

MEETINGS.

The annual meeting of the Institute shall be held on the third Tuesday of August in each year. The Institute may at a regular meeting select the place for holding the next regular meeting. If no place is selected by the Institute it shall be done by the council.

Special meetings may be called whenever the council may see fit; and the secretary shall call a special meeting at the written request of twenty or more members. No other business shall be transacted at a special meeting than that for which it was called.

Notices of all meetings shall be mailed to all members, at least thirty days in advance, with a statement of the business to be transacted, papers to be read, topics for discussion and excursions proposed.

No vote shall be taken at any meeting on any question not pertaining to the business of conducting the Institute.

Every question that shall properly come before any meeting of the Institute, shall be decided, unless otherwise provided for in these rules, by the votes of a majority of the members then present.

Any member may introduce a stranger to any regular meeting; but the latter shall not take part in the proceedings without the consent of the meeting.

XI.

PAPERS AND PUBLICATIONS.

Any member may read a paper at any regular meeting of the Institute, provided the same shall have been submitted to and approved by the council, or a committee duly authorized by it for that purpose prior to such meeting. All papers shall become the property of the Institute on their acceptance, and with the discussion thereon, shall subsequently be published for distribution. The number, form and distribution of all publications shall be under the control of the council.

The Institute is not, as a body, responsible for the statements of facts or opinion advanced in papers or discussions at its meetings, and it is understood, that papers and discussions should not include personalities, or matters relating to politics, or purely to trade.

XII.

AMENDMENTS.

These rules may be amended by a two-thirds vote taken by letter ballot in the same manner as is provided for the election of officers by letter ballot, PROVIDED, that written notice of the proposed amendment shall have been given at a previous meeting.

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MINUTES OF THE FOURTH ANNUAL MEETING.

MARQUETTE IRON RANGE.

Tuesday, August 18, 1896.

Members and guests assembled at the Nelson House, Ishpeming, on Tuesday morning, where they were received by the local Committee of Arrangements, of which Mr. Geo. A. Newett was chairman and Mr. A. J. Yungbluth secretary. The local committee had arranged a program for the meeting, which was followed with much pleasure by all.

At the request of the secretary of the Institute, Mr. Newett had prepared a description of the mines to be visited and the country to be traveled over, which was published by the Institute and distributed as a guide to those attending the meeting.*

Tuesday afternoon was spent in visiting the mines about Ishpeming, in the following order: Lake Superior, Cleveland Lake Shaft, Lake Angeline, Section 16, Salisbury. The Excelsior furnace was reached in time to see the casting, which ended the sightseeing for the day.

Tuesday night a business session was held at the Ishpeming Opera House, which was called to order by Mr. Per Larsson, vice-president, who read a telegram from President John Duncan, expressing regret that at the last moment he had been prevented from attending the meeting.

After some extemporaneous words of welcome and cheer from the Chair, Mr. E. F. Bradt read a paper entitled, "The Electric Haulage Plant of the Pittsburgh and Lake Angeline Mining Co." This was followed by a similar paper presented by Mr. James E. Jopling, on "The Electric Haulage Plant of the Cleveland Lake Shaft."

After the discussion of both these papers, Mr. C. T. Mixer read his paper, "Methods of Sampling Ore."

It was then moved and carried that the Chair appoint an Auditing and a Nominating Committee.

The committees appointed were:

Auditing Committee—T. F. Cole and W. Fitch.

Nominating Committee—James E. Jopling, W. J. Olcott, Wm. D. Van Dyke, Geo. H. Abeel and Graham Pope.

Meeting adjourned.

*Mr. Newett's description is republished in this volume.

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Wednesday, August 19th.

On Wednesday morning a special train on the D. S. S. & A. railway carried the party to visit the Champion, Republic and Jackson mines.

After lunching at Negaunee, the train was again boarded and a visit made to the Buffalo mines, where the party was transferred to a special train on the Lake Superior and Ishpeming railway, which had just been opened to traffic.

This new railroad, built to carry ore to Lake Superior for shipment, was next inspected while the party was being carried to the new ore docks just completed at the terminus of the road. After spending some time at the docks the party dispersed, to reassemble for dinner at the Hotel Superior, Marquette.

The second and final evening session was held in the rooms of the hotel. Mr. Per Larsson again presided.

The report of the council was read by the Secretary. The report included a financial statement and a list of names of applicants for membership which had been approved by the council.

The report of the council was unanimously approved and the applicants for membership were duly elected.

Reports of committees being called for, the Auditing Committee reported that it had audited the accounts of the Institute.

The Nominating Committee reported as follows:

President, Wm. G. Mather; vice-presidents, Geo. H. Abeel, J. F. Armstrong; managers, Graham Pope, Wm. Kelly, C. H. Munger; treasurer, Geo. D. Swift; secretary, F. W. Denton.

The candidates proposed by the committee were elected unanimously.

It was then moved and carried that Mr. Kelly and Mr. Munger be requested to escort Mr. Mather to the chair.

After a few remarks by Mr. Mather, expressing his appreciation of the honor of being elected president, Mr. T. F. Cole read a paper entitled, "A Single Engine Hoisting Plant."

The Secretary then read a record of a pump test prepared by Mr. Sturtevant, who was unable to be present.

It was then voted that the thanks of the Institute be extended to the local committee and to the railroads for the successful and pleasant program which had been arranged by them for this meeting. The president announced that Mr. Hiram Burt had prepared, in an adjoining room, an exhibition of old papers, maps and instruments connected with the early geological work in the Lake Superior region.

The meeting then adjourned.

Thursday, August 20th.

On Thursday morning the party assembled at Ishpeming and was carried by a special train, provided by the Chicago and Northwestern railway, to Escanaba.

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After inspecting the docks at Escanaba, the steamer Lotus conveyed the party to Gladstone to visit the new charcoal furnaces.

Luncheon was served at Gladstone, after which the party returned to Ishpeming, and the fourth annual meeting of the Institute closed.

CANDIDATES APPROVED BY THE COUNCIL AND ELECTED TO ACTIVE MEMBERSHIP.

Anderson, W. H.,	Esselstyn, John W.,	Pascoe, Peter W.,
Baker, Fred. J.,	Fisher, James,	Philbin, D. M.,
Bayley, W. S.,	Gill, William,	Prescott, F. M.,
Braastad, Frederick,	Hall, C. H.,	Quinn, John H.,
Burt, Hiram,	Hughes, C. W.,	Redfern, J. A.,
Chipman, J. C. W.,	Johnston, Wm. H.,	Rough, James H.,
Clancy, James,	Kaufman, Louis G.,	Scott, Dunbar D.,
Collick, Alfred,	Kirkpatrick, Clark,	Smith, Wm. W.,
Dubois, Howard W.,	Kruse, Chas. T.,	Storey, Jos.,
Duncan, Murray M.,	Lawrence Chas. E.,	Suess, Jos. E.,
Elliot, Mark,	Lutey, John T.,	Robinson, A. W,
Ericson, Rudolph,	Mason, Clarence G.,	Rose, R. S.

FINANCIAL STATEMENT.

Receipts.

Dues from members	$670.00	
From sale of extra copies of proceedings	20.00	
Total receipts	$690.00	$690.00
Balance March 8, 1896		90.94
		$780.94

Expenditures.

Expenses 3d annual meeting	$104.55	
PRINTING AND STATIONERY.		
1,000 copies of Vol. III, including cost of plates, freight and express	340.35	
Other printing	25.35	
Postage	38.95	
Secretary's salary	100.00	
Telegrams	2.50	
	$611.70	$611.70
Balance in treasury		$169.24

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REGISTRY OF MEMBERS AND GUESTS IN ATTENDANCE AT THE FOURTH ANNUAL MEETING.

Geo. A. Newett,
B. E. La Londe,
W. Fitch,
F. J. Baker,
J. M. Vickers,
E. V. Palmer,
A. E. Buzzo,
Graham Pope,
Frank McM. Stanton,
H. W. Fesing,
A. J. Yungbluth,
John H. Quinn,
James H. Rough,
J. C. Kirkpatrick,
Geo. D. Swift,
W. G. Mather,
Wm. Kelly,
N. P. Hulst.
E. F. Bradt,
C. T Mixer,
T. F. Cole,
F. W. Nelson,
Fred E. Vickers,
A. O. Jopling,
W. J. Olcott,
W. H. Nelson,
F. W. Sperr,
James Clancey,
J. H. Karkeet,
Jas. Ames,
L. B. Miller,
S. H. Pitkin,
Geo. H. Abeel,
W. E. Dickinson,
L. G. Kaufman,
C. E. Hendrick,
W. H. Anderson,
D. T. Morgan,
Austin Farrel.
Mark Elliot,
Aug. Bueling,
J. F. Armstrong,
Wm. D. Van Dyke,
H. T. Hulst,
J. H. Malloy,
Chas. W. Hughes,
C. T. Fairbairn,
A. I. Findley,
W. S. Bayley,
L. J. Merritt,
Per Larsson,
D. D. Scott,

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ELECTRIC MINE HAULAGE PLANT.

Pittsburg and Lake Angeline Iron Company, Michigan.

BY E. F. BRADT, MINING ENGINEER.

In the fall of 1892, when the work of opening the first level of the P. & L. A. I. Co.'s East End mine had been completed, and the extent of the level, together with the number of mills and their distances from the shaft had been determined, Superintendent Walters began to consider and to devise more economical methods of tramming them by hand.

It was desired to hoist all of the ore through one shaft; in fact, the surface conditions, such as room available, etc., almost necessitated the use of but one shaft.

Late in the winter following Capt. Walters, in company with Mr. S. A. Parnall, visited and examined the electric haulage plants in operation at Streeter, Ill., Scranton, Pa., and northern New York. Tramming with mules and by endless rope were also investigated.

While the construction and operation of the plants visited varied considerably and some of the plants were not altogether satisfactory, yet, after inspecting the plant at Scranton, and obtaining information and figures, Capt. Walters became convinced that with certain modifications applicable to an iron mine, electric haulage was the system to adopt.

Upon his return correspondence was at once entered into with the General Electric Company, and two of their locomotives, a generator, and the necessary appliances for installing a plant were ordered, and the work of putting the drifts in shape for the plant, by making suitable curves, etc., was immediately begun.

The accompanying map shows the plan of the level, and the number and positions of the mills. The ore lies in a basin

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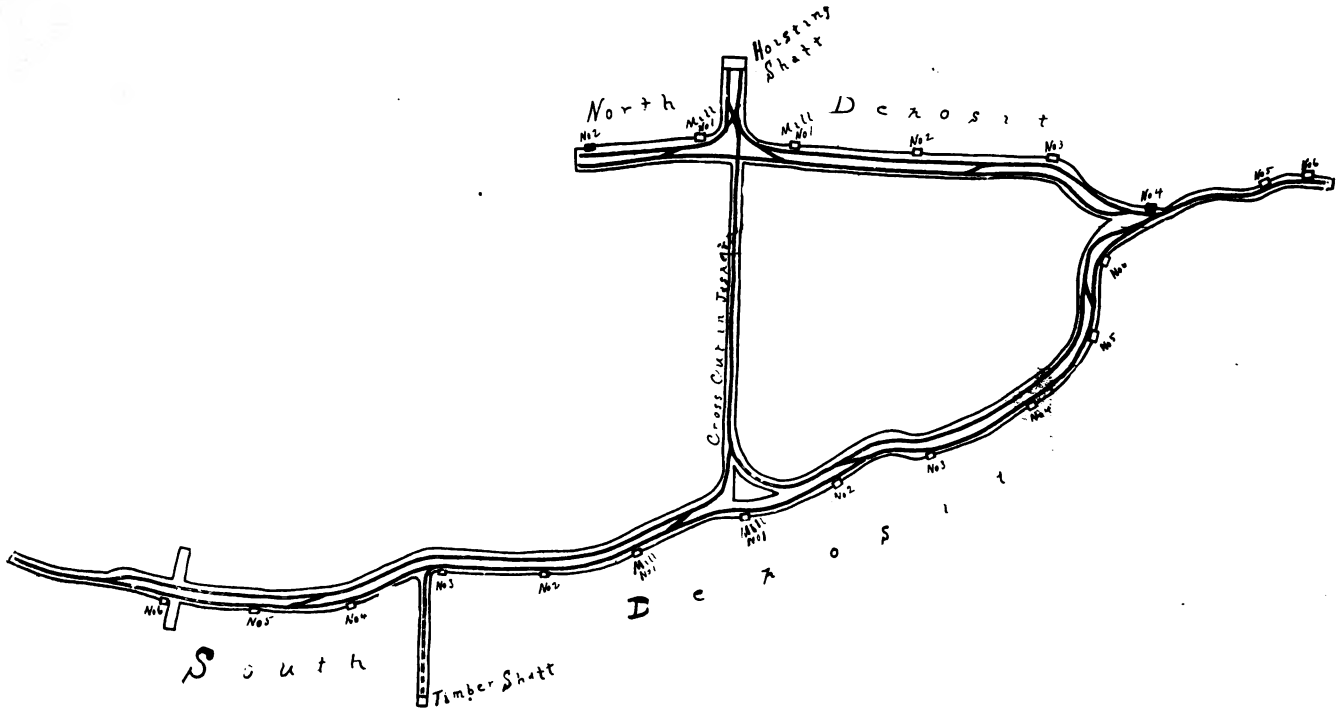

PLAN OF FIRST LEVEL.

P. & L. A. CO.'S EAST-END MINE.

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or fold, whose axis dips west, and comes to a point at the east end of the mine, and for convenience will be divided into north and south deposits.

The main drifts through the ore deposits are sixteen feet wide and are timbered for a double track with a clear passage of six feet in width for the locomotive and cars. A cross-cut north and south through jasper unites the two deposits and contains a single track.

As a rule, the mills are so located that the cars may be loaded from them while standing on the main tracks.

In describing the plant we will begin with the track, which, in the ore deposits, is double, and provided with cross-overs, as shown in the plan. It is constructed of steel rails twenty-six feet long and weighing thirty pounds to the yard, joined with ordinary straps or fish plates. The ties are 4 x 8 inches, and of hemlock, laid two feet from center to center.

The switches are the ordinary stub switch, with blind switch stands, and the gauge of the track is thirty inches.

The locomotives* used are known and described by the General Electric Company as the "TMM locomotives," and I quote from their catalogue in describing them:

"They are 30 horse-power; speed, six miles per hour; draw-bar pull, 1,500 pounds; gauge, 30 inches; extreme dimensions in width, 51 inches; length, 10 feet 9 inches; height, 32 inches, and weight, 9,000 pounds each.

"The motors are water-proof, the parts shielded from moisture and dust, and at the same time all the working parts are easily accessible in case repairs are necessary.

"The body of the locomotive is made up of two massive cast-iron side frames rigidly bolted to heavy end beams of the same material, and is supported by spiral steel springs resting upon the bearing boxes. The wheels are located within the axle bearing boxes.

"The levers controlling the rheostat, reversing switch, sand box and brake are within easy reach of the operator.

*A view of one of these motors was published as a frontispiece in Vol. III.

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"The locomotives are fitted with steel gearings, and a double elbow trolley located on top of the center of them, which permits their running either forward or backward without the usual delay in shifting the trolley drum."

The electric current is supplied by an 85-horse power Thompson-Houston generator, motor type. It has a speed of 900 revolutions per minute, is wound for 500 volts and 110 amperes, and has a capacity of 62,000 watts.

It weighs 10,319 pounds and rests upon a 2,220-pound cast iron bed-plate, upon which it can slide, and is easily adjusted by means of a screw and lever for the purpose of tightening and loosening the driving belt.

The following I take from the General Electric Company's catalogue. "The regulation of the power output of the generator is automatic and is independent of mechanical governors, and is entirely due to the action of the electrical current in the fields and armature of the generator itself, producing perfect and unvarying regulation and giving a maximum of economy which can always be depended upon.

"The series-shunt winding of the generator causes it to respond instantly to the widest variation in the load without requiring any attention on the part of the engineer."

The generator, in turn, is driven by a 12 x 36-inch 100 H. P. Corliss engine, built by E. P. Allis & Co., of Milwaukee.

The current is conducted from the generator to the trolley wire underground, and from the return wire to the generator by means of two water-proof lead-covered cables of a capacity to transmit eighty electrical horse power with a loss of ten per cent electrical energy.

The cable is carried overhead from the generator to the shaft house, thence down the shaft, incased between two 2-inch planks, ten inches wide, each grooved to a size snugly fitting one half of the cable. The planks are nailed to the side of the shaft, thus thoroughly protecting the cable from injury.

The cable is made of thirteen No. 10 wires, twisted together, moulded in rubber and covered with lead about one-eighth inch

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thick, which in turn is covered with tarred twine, thus making a water-proof and thoroughly insulated conductor.

The trolley wire is No. 0 hard drawn copper wire, suspended at a uniform height of six feet above the track by means of cap and cone insulators fastened to 2-inch plank with lag screws.

The purpose of the plank is to afford protection for the trolley in case it leaves the wire. They are 2 x 12-inch, dressed on the lower side, and nailed to the timber above. Along each edge, on the under side of the plank, are nailed triangular strips projecting downward about two inches to prevent the trolley from leaving it. They are covered with tar to preserve them.

The return wire is a No. 0 tinned soft drawn copper wire, placed in the center of the track and is connected with each rail by means of a cross wire attached to the bond wires on either side.

The rails are bonded at alternate joints by means of a short wire of the same size and quality as the return and cross wires. The bond wires are inserted in holes drilled in the flanges of the rails and fastened with channel pins and then soldered.

In the operation of the plant the motor readily rounds the sharp curves varying in radius from 12½ feet up, and thus far no difficulty has been experienced in handling any number of loaded cars, either with or against the grades, which are from nothing to three per cent, and which are in favor of the loads when hauling towards the shaft.

The usual number of cars handled in a train is from four to six, this being the most convenient number for loading from each chute and handling at the shaft, the room for standing cars being somewhat limited.

The train of loaded cars is taken from the mill to the shaft and empty cars put in their place immediately. The loaded cars from another mill are then taken, and so on throughout the mine, no regular order being observed, the trains being taken from the mill most crowded.

The cars used in handling the ore carry two tons, and are made entirely of iron. The body of the cars are six feet long,

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four feet wide on top, three feet wide in the bottom, about two feet deep, and is bolted to a bed-piece made of 2½ x 7-inch channel iron. The sides of the car are three-sixteenths of an inch thick and the bottom half an inch. The front axle is fixed to the bed-piece, while the hind axle is attached to the front axle by means of two bridles, and remains on the track in dumping.

The axles are made of 2½-inch square iron bars, and the journals are 2¼-inches. The wheels are 14 inches in diameter, and self-oiling. The car dumps endwise through a chute into the skip, the door of the car being opened by means of a tumbling rod operated from the rear end of the car.

In the train, the cars are coupled with links, and the train operated by a motorman and helper. The duty of the helper being to couple the cars, throw switches, etc.

Again referring to the plan of the level, it will be seen that there are twenty mills located at varying distances from the shaft, the shortest distance being 125 feet and the longest 1,020 feet, while their average distance is 570 feet.

The locomotive not only handles the ore from these mills, but also hauls all the timber used in the mine.

During the year ending May, 1896, 171,870 tons were trammed and hoisted, and the locomotive could easily have hauled all the timber needed and have trammed 240,000 tons in the same time with but slight additional total cost. During two and one-half months of the year, the mine was idle, owing to a strike.

In giving the cost of operating the plant, I give the figures for the above year, this being the only year in which tramming was done exclusively by electric power. All expense, whatsoever, connected with handling the ore after it is put in the mills being charged to the electric haulage account. Lack of time prevents making an analysis of the account and giving the cost of tramming alone.

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During the year mentioned there was charged to the account:

Labor	$14,586.65
Supplies	71.50
Illuminating oil	40.65
Lubricating oil	50.20
Lumber and iron	167.00
Fuel	1,715.50
Making a total charge of	$16,636.50

This gives 9.68 cents per ton on the ore hoisted.

In the $14,586.65 for labor is included the labor of filling and dumping the cars, repairing tracks, cleaning ditches, handling timber, salaries of electrician, motormen and helpers, the labor of putting in 3,970 feet of single track and the same number of feet of wire in installing the plant on the second level. Also, during the two and one-half months the mine was idle, a portion of the expense of pumping and the salary of the electrician was included in the account.

During the year an electric hoist was installed and the total expense of operating it was charged to the account.

I will say here that it is optional with the contractors whether they hoist their own timber or have the company do it, but in all cases where the company hoists the timbers there is a reduction in the price of mining of twenty-five cents per foot which is not credited to the account. The interest on the investment and the depreciation in value of the plant is not included in the account.

But one locomotive is used at a time, there being but one motorman and helper on each shift. Previous to installing the plant on the second level the other locomotive was held in reserve in case of repairs. Since which time one of the locomotives has been placed on the second level and tramming is done alternately on the two levels. As soon as the ore on any portion of the level is removed and the mill disappears, a mill on the second level takes its place, thereby retaining the original number.

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The following is the cost of installing the plant:

Amount paid to the General Electric Company for two locomotives and one generator complete, wire, etc., and the services of Mr. H. M. Hawley, their representative, who installed the plant, was	$12,400.00
One 100 H. P. engine	1,486.00
Rails and supplies	1,236.18
Lumber	254.24
Supplies from mine and shaft	820.47
Labor	2,007.85
Total	$18,204.74

For assistance in obtaining the above information regarding the plant I am indebted to our electrician, Mr. Geo. M. Baker, who has had charge of the plant since its installation.

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UNDERGROUND ELECTRIC HAULAGE PLANT.

Cleveland Lake Mine, Ishpeming, Michigan.

BY JAMES E. JOPLING, MINING ENGINEER.

The electric haulage plant in the Lake Mine was installed during the year 1893-4, while Mr. Fred P. Mills was agent of the company. Explorations under the bed of Lake Angeline, which has since been drained, had proved that upon the first level the length of ore in what is known as the "Lake Deposit" was over 2,400 feet, and that the distance from the footwall of the north vein to the footwall of the south vein of the basin was over 600 feet, measured at the widest. As arrangements had been made to take all this ore through No. 1 shaft, it was evident that a haulage plant of some kind was necessary.

In January, 1893, Mr. Samuel Parnell, the mining engineer, accompanied by Capt. James Reed, inspected several such plants in the coal regions of Pennsylvania and Ohio. As a result of investigations a trial was made the same year with an electric haulage plant, consisting of a small generator, and the motor which is still running on the second level. It was not until 1894 that the plant was completed in its present shape, the electrical equipment being furnished by the General Electric Company.

The generating machinery is installed in the engine house in which is the hoisting plant described at a former meeting of the Institute.

The engine is a 16x42-inch Corliss, of 115 H.P. at 95 pounds steam pressure, though at present 120 pounds is used. It has separate wrist-plates and eccentrics for admission and exhaust valves. It is run at 84 revolutions per minute, and is connected direct to a 15-foot drive wheel with 24-inch face. A double leather belt connects the generator, which has an 18-inch pulley.

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The generator is a direct current machine of the multipolar type, and runs at 650 revolutions, giving an electromotive force of 220 volts without load, and is overcompounded for 240 volts at full load. Its capacity is 420 amperes. A blast of air from the compressor is used to keep the bearings cool.

On the switchboard is a circuit breaker which is set to automatically open the circuit when the current reaches 300 amperes. There is also a lightning arrester, and the usual voltmeter and ammeter, while the switches are so arranged as to entirely cut off the current from the mine, or from either level.

The engine and boiler houses and dry are all lighted from the same machine, the lamps being 16 candle power, 220 volts. These are connected so as to give light, even if the current is for any reason cut off from the mine. The two main wires leading down the shaft are No. 0 copper, one for each level, and are encased in rubber inside a lead tube, which is again covered with asphalt paint. They are protected by being placed against the back of the shaft in a plank grooved to receive them, another plank being spiked on to hold them in place. The return is a No. 00 bare tinned copper wire fastened to the side of the shaft.

On the levels the trolley wires are supported by insulators of the regular mining pattern at a height of about six feet six inches above the rails. These insulators are fastened to the under side of a 2-inch plank which is spiked to the caps of the drift, over the center of the track. At intervals a branch copper wire of No. 12 gauge leads to a 220-volt, 16 candle power lamp, which is connected with the return. There are about one hundred of these lights at different points along the track, using a current of about 15 amperes. The return upon both the levels is also a No. 00 tinned copper wire, and is connected with the rail bonds in the usual manner. The rails on the motor tracks are 40 pounds to the yard, and the ties 6 x 6 inches by 4 feet long. The gauge is two feet six inches.

The accompanying drawings show the alignment of the first and second levels. As will be seen, it was designed to make a complete circuit on each level, consequently there is

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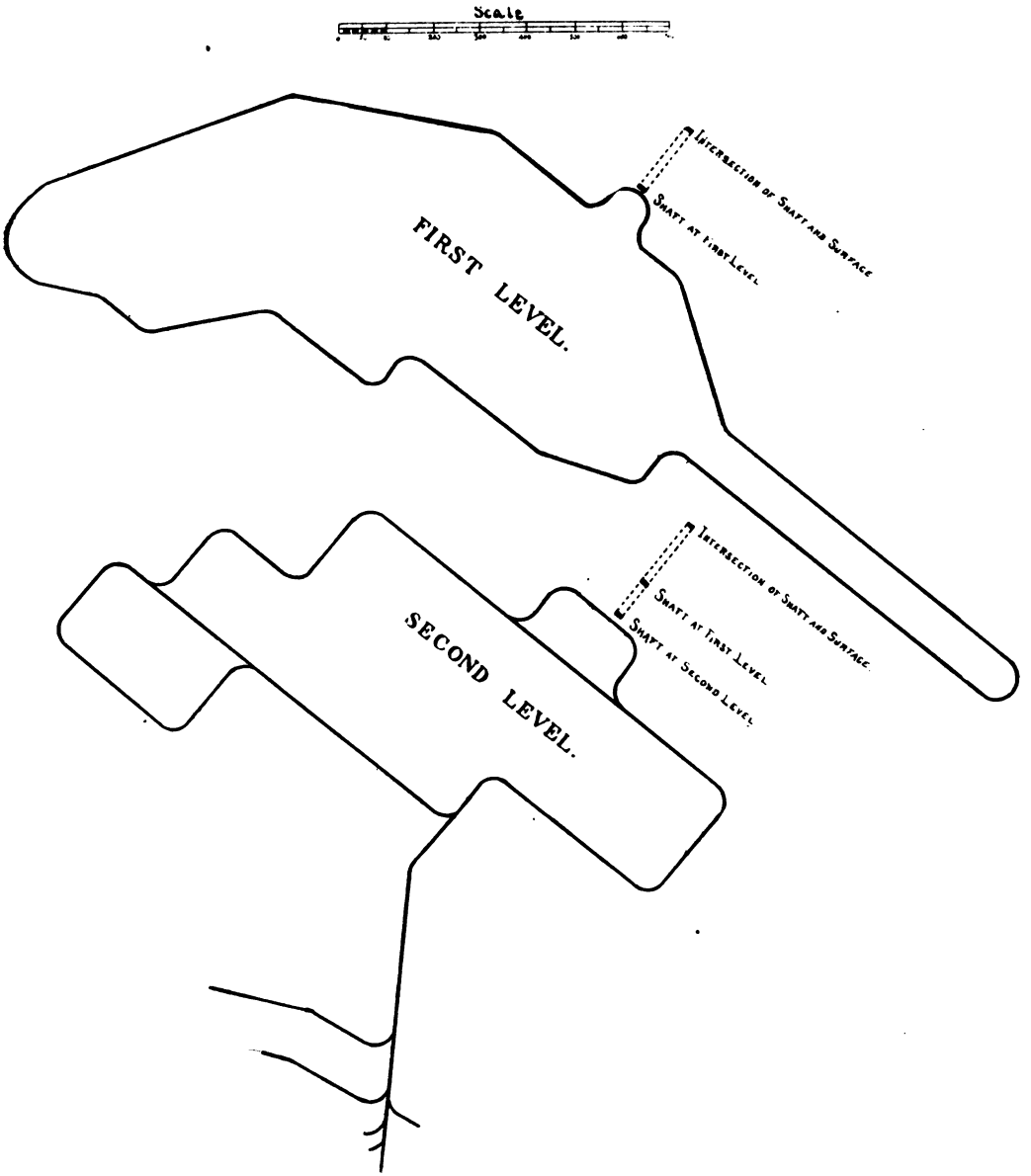

PLAN OF ELECTRIC HAULAGE TRACKS

CLEVELAND LAKE MINE, ISHPEMING, MICH.

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little or no grade, except where the track has been extended south on the second level to the so-called "Lake Angeline" deposit, which is in the same vein as the East End mine of the Pittsburg and Lake Angeline Iron Company. Here the grade is less than one per cent. The minimum curve has a 42-foot radius.

The motor on the first level is a 65 H. P. machine, upon four 24-inch wheels, which are of cast iron with steel tires shrunk upon them. Both axles are geared to one armature of the gramme ring type. The wheel base is 3 feet 6 inches, and the size over all is 11 feet by 4 feet 2 inches. The weight of the motor has been reduced from eleven to nine tons, and the speed is six miles an hour with a train load of fifty tons. The trolley pole is three feet long, and the wheel is swivelled to adjust itself to the curves. There is a headlight of two incandescent lamps. The drawhead is of wrought iron, and the brake, which is operated by hand, is of the toggle pattern, similar to the steam brake of a locomotive.

The twenty tram cars on this level are of iron, and stand 4 feet 3 inches above the track, by 11 feet long over all. The hopper is 3 feet 10 inches by 7 feet 2 inches at the top, and 2 feet by 2 feet 10 inches at the bottom, and holds about three tons of hematite ore. The door at the bottom is hinged at one end, and drops when the catch is released, again closing automatically as the car is pulled over a roller set between the rails, by which the door is raised into place. The wheels are loose upon the axles, have a babbitt bushing and are self-oiling.

The motor on the second level is smaller and of higher speed, running ten miles per hour with a 25-ton train load. It is a 30 H. P. machine, having four 30-inch wheels, with an armature geared 5 to 18 on either axle. Its weight has been increased from four to seven tons. The wheels are ordinary car wheels and have lasted two years, or the same as those described on the first level motor. The wheel base is four feet and the motor occupies a space of 11 feet by 4 feet 2 inches over all. The trolley has an electric light attached. The brake is of the ordinary street car pattern.

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The cars on this level are of iron, though the frames are stiffened with wood and the wheels are of the ordinary railway car pattern. The cars, which are of course filled from chutes, are dumped into pockets located above the skip, and holding a single load, and the ore is released from the pocket by a door sliding at the same inclination as the shaft. No gates are used for the skips which run in balance.

It might be of interest to say that checks numbered to denote the grade of ore are attached to the cars by the chute men, while an indicator worked by a rope is set when the ore is hoisted, to show in the shaft-house what grade is coming up.

The delays due to repairs, of course, vary considerably. An extra armature and rheostat are kept on hand for each motor, so that little time is lost from burn-outs, changes being made, when possible, out of working hours. The only burn-outs on the large motor have been in the rheostat, and the switch has been out of order once. The small motor has caused more trouble, the armature having been burnt out several times when overworked. It requires about four and one-half days to rewind the whole armature, and about one and one-half days to repack the rheostat. The carbon brushes are renewed once a month, and the brake shoes once in two months. The car wheels have to be rebabbitted about once in every two or three months, and at present the cars are receiving a general overhauling after two years' service.

The cost of tramming ore, including the proportion of engine house expense and maintenance, the wages paid to motor men and chute men, have been as follows:

1894	$.039 per ton.
1895	.045 per ton.
1896 to August 1st	.048 per ton.

This increase is partly due to a rise in wages, and partly to the greater average length of tram. The wages paid skip-tenders, the small amount of hand tramming, the cost of hauling timber and filling rooms with sand and rock have not been included in the above.

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The train crew consists of a motorman and a switchman, and from two to four chute-men, who work either eight or ten hour shifts, according to tonnage needed. The trains on each level usually consist of six cars, and when possible, the original method is adhered to of dropping empties at the chutes, while picking up the loads ahead.

The cost of installation has been as follows, up to February, 1895:

Foundations	$1,050.06
Machinery	10,337.15
Drifting	25,469.79
Tracks	7,741.84
Wiring	4,988.20
Total	$49,587.04

The amount put down to drifting includes the necessary curves, and in certain places a more permanent route in the solid rock; also the long rock drift on the second level between the two deposits. Since February, 1895, the extension of track and line has been charged to operating expenses.

DISCUSSION.

MR. J. F. ARMSTRONG: "How does the cost of electric haulage at the Lake Angeline compare with that of the old system of haulage?"

MR. BRADT: "I have no figures and cannot say."

MR. W. J. OLCOTT: "I do not see any economy in electric haulage over the old system. The figures show a cost of over nine cents a ton. We are tramming at the Tilden mine from 350 to 1,100 feet, with an average of 526 feet, for 7½ cents a ton. Our men made $1.92 a day."

MR. G. A. NEWETT: "Does that cost include cost of handling timber?"

MR. OLCOTT: "No. We use but little timber. The cost last year was 1½ cents per ton."

MR.———: "I think we had better get the comparative cost. In Mr. Jopling's paper he says that some accounts have

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not gone into the cost. Mr. Bradt has included the tonnage, Mr. Jopling has not. We need some comparative statement to enable us to tell where the difference in cost comes in."

MR. BRADT: "I did not have time to separate the accounts. Our company does not see fit to keep more than one account in connection with its tramming. All the cost in handling the ore at the East End mine is put into the electric haulage account. The different items include the installing of the plant on the second level, putting up wire, etc. I have taken the account as it stands not having had the time to separate it. The cost of hoisting the timber into the raises is included in the $.0968. We are working our mine from the top down and as we go down some portions are worked out before others. As soon as we come down to where the timbers begin to crush we begin to put up raises from below, and tram from the level below. That is what we have been doing. We spend no time in trying to keep the drifts open."

MR. WILLIAM KELLY: "Up to the present time by far the greatest amount of tramming in our mines has been done by hand power. Until quite recently it was, with the exception of animal power used at one of the Marquette mines, exclusively used. Some years ago the wire rope haulage was introduced at the Chapin, and more recently we have had the electric plants that we have heard from this evening. Still more recently animal power has been tried at some of the mines. Four different systems, wire rope, electric, animal and hand-power. The question suggests itself: Are these different systems adapted to different conditions? For a basis of discussion I would propose that the wire rope haulage is adapted to mines where the amount on a level is large, and the distance great, the levels being straight; that electric haulage is suited to mines where the quantity of ore is large and the distances great, but the levels are tortuous, and branches are necessary for outlying portions of the ore, the electric system being more flexible, but somewhat more expensive than the wire rope haulage; where the quantities on a level are smaller and the distances not quite so great, and little flexibility is necessary, animal power within a proper sphere is ap-

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plicable; but where the quantities are still smaller, and the distances less, we are still obliged to use hand power. I would like to inquire of the Institute whether they think such a propo sition as I have suggested is a proper one."

MR. FITCH: "I think that Mr. Kelly would have to qualify his statements in regard to the adaptibility of animal power under the conditions he speaks of. How would he get animals down to the different levels and get them up again? Where the mine is large and it is possible to handle the animals and keep them underground, he might use them, otherwise he would have to limit their use to surface tramming, as at the Republic, where animal power has been used more than any anywhere else."

MR. KELLY: "There are some places where mules could not be taken, and certainly there are places where *large* mules could not be taken, but *small* mules could be taken through rather small openings, and through ordinary sized shafts mules can be lowered that will do exceedingly good work, and be a great improvement in economy over hand power. I met Mr. Bacon on the train one day, going down from Duluth. We had been talking about trying mules. I had seen them used at the Norman mine and asked Mr. Bacon regarding them. He said that they intended purchasing some more. He asked me about what sized mules we proposed to get. I told him that we were intending to buy 54-inch mules. "Well," he said, "you are buying them by the inch, we are buying them by the pound."

MR. T. F. COLE: "There is such a marked difference between the cost of tramming in the two papers that I wish to go still further. Mr. Bradt has taken in an entire year during which we had a strike and he has charged in items that could not properly be charged to tramming. In addition he has not given credit for work done, as the account was charged with raising timber. The tonnage was not treated by Mr. Jopling. In Mr. Newett's pamphlet we have here under the head of the "Cleveland Angeline:"

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"Engine house expense, motormen and brakemen. . . .$.0201
Men running underground pockets and chutes. 0185
Small amount hand tramming and tending skips. 0128

Total cost per ton . . . . . .$.0514

This test was based on a monthly product of 41,604 tons. The motor capacity is 60,000 tons per month for two."

MR. JOPLING: "Those are the figures for the Cleveland Lake Shaft haulage plant for the month of October. My figures embrace those first two items only, the amount of hand tramming and tending skip is not included. The figures here quoted are for the month of October, 1895; the total tonnage was about 170,000 tons."

MR. COLE: "I still am of the opinion that had Mr. Bradt had the time to go into the matter a little more carefully so as to have given credit, that the cost of $.0968 per ton would have been reduced materially. I want to get the exact cost of handling the ore at the Lake Angeline mine, and suppose it would be very near that at the Cleveland. The costs cannot be very far apart for the tonnage handled is about the same.

MR. OLCOTT: "The remarks I have made are not to bring out the fact that we are doing some cheap tramming, but in order to get at the comparative merits of the two systems. Mr. Jopling has not included one of the chief costs of tramming, namely, shoveling. The cost at the Tilden mine includes shoveling.

MR. FITCH: "Mr. Bradt included the cost of putting in work which is not generally included. I should also find fault with the charging out to the cost of installation the making of drifts, as has been done in Mr. Jopling's paper. A drift being put through is part of the opening expense of a mine. It might just as well have been charged to the cost of stoping as to the cost of tramming. I think such a charge should be eliminated."

MR.———: "It seems to me that where Mr. Bradt has charged up to the cost of tramming the installation of electric equipment that cost of drifting should be included in the years of production and not included in one year."

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MR. KELLY: "The subject under discussion seems to be drifting away to a question of book-keeping. I believe that if these gentlemen had got together beforehand, and decided what they would consider tramming and what not, their figures would agree very closely."

MR. BRADT: "This discussion is just what I expected. It is unfortunate that I did not get to the figures in time to analyze them."

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METHODS OF SAMPLING IRON ORE.

BY C. T. MIXER, ISHPEMING, MICHIGAN.

Mr. Brown's excellent paper on the "Distribution of Phosphorus and System of Sampling at the Pewabic Mine," read at the last meeting of the Institute, proved of such interest, and provoked so much discussion, that our Secretary thought a similar paper in connection with some of our Marquette County mines, might also prove interesting, and be at least useful for reference in the Proceedings of the Institute. I will accordingly endeavor to present to you briefly the schemes that are adopted at some prominent mines to separate properly their various ores, and will include a few remarks upon the occurrence of the iron and phosphorus in some of the deposits.

PITTSBURG & LAKE ANGELINE IRON COMPANY.—The Lake Angeline Company adopts the plan of sampling each stope every other day, alternating between the East End mine and the Old mine. A special man is detailed for this work, and it is also his duty to properly describe the places he samples, and call the mining engineer's attention to anything unusual in connection with the taking of the sample. He uses his discretion as to whether to take from the breast or the broken ore. Each sample is sufficient in amount to fill a small saucer, in which it is dried during the night, is ground the next morning, and the results obtained from the laboratory in the afternoon. Results can be judged by the eye at noontime, and any changes made if necessary. Still, it is not usual to condemn a place upon one sampling, unless the character of the ore has already been apparently changing, or has come from a bad locality.

In the East End mine, south deposit, for a distance say of 100 feet west and 200 feet east of the main cross-cut, the

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phosphorus is found to be very high right under the silicious capping, but on coming down to the first level, the character changes, so that all the east side becomes bessemer, and a small portion of the west side also. In the extreme east end of the mine, the upper portions were put out for first class, since the non-bessemer zone was in too small quantity to separate easily.

When the bottom of the basin is reached, the phosphorus increases to perhaps .5 per cent, which indicates that the phosphorus has been leached from the upper portions and concentrated in the trough.

In the north deposit, west of the main cross-cut, the ore is all within the bessemer limit, running about .020 in phosphorus, but also increases in amount, as it approaches the trough. In the south deposit, 300 feet west of the main cross-cut, the phosphorus is extremely irregular, and if this ore were mined alone would scarcely be bessemer. As it is, nearly one-half is separated as bessemer. In the whole mine about 80 per cent is secured within the bessemer limit of .045.

In the old mine the phosphorus is quite regular, ranging from .007 to .035. The ore, much of which is of the hard variety, is mainly classified with regard to the iron content. Two grades are made, the first known as No. 1 hard, containing about 66 per cent of iron and .015 in phosphorus, and the second, called Sheffield, containing 61 per cent in iron and .030 phosphorus.

After the ore from these mines is hoisted, car samples are taken, varying in number according to the size of the cars, and no further samples are taken until the ore reaches its destination. Last year samples were also taken at the shipping port, but these have since been discontinued as being an unnecessary expense and trouble. During the winter season a sample is taken of each grade of ore from each skip hoisted, and these are combined into weekly samples for analysis. A daily stockpile sample is also taken and made into a weekly sample. This system of sampling has always proved entirely satisfactory, and at the end of the season the average results

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of cargo analyses have always checked closely with the mine figures.

CLEVELAND CLIFFS IRON COMPANY.—At the Cleveland Lake mine the practice is adopted of sampling each stope every day, and when drifting sampling every ten feet. Chute samples are also taken, sometimes representing two or three different contracts, and the results from these are mainly relied upon in determining the make-up of the various grades. Of these grades there are at present seven, with the following general limits:

	Percentage.	
Bessemer No. 1	Iron 66.00	Phos. .030
Bessemer No. 2	Iron 63.00	Phos. .040
East End	Iron 60.00	Phos. .050
Lake	Iron 60.00	Phos. .080-.100
Ishpeming	Iron 57-58	Phos. .063-.070
Silica	Iron 47.00	Phos. .045
Silica	Iron 47.00	Phos. .030

The ore for each of these grades is then sampled at the surface and is kept for a daily sample, unless some special grade is called for. In case any emergency arises the railroad cars are also sampled, and when shipping from stockpile the cars are always sampled. The ore is next sampled at the shipping port, as it is being loaded into the vessel, and the sample returned to the mine for analysis.

The underground samples are generally in the crusher room by 6 a. m., and the results are obtained from the laboratory by 2 or 3 p. m. This enables any changes to be made that evening, if necessary. The car samples are brought in at night, and dry over night, the results being obtained the next afternoon.

During the past spring a new scheme in the form of a daily chart, having columns for recording the daily analyses of stopes, outputs and grades, was tried, it being thought that it would aid in systematizing the grading, and show at a glance what could be and was being accomplished with the material at hand. After a few weeks the system had to be abandoned, for several reasons. The averages of the stopes and drifts did not always agree with the samples taken by the skiptender,

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there sometimes being great discrepancies. This was partly due to the fact that ore that was sampled and broken in drifting might or might not go up the day reported. This, of course, had to be at the discretion of the mining captain, who might have to change the place of working of a party, depending on conditions that might arise, such as caving ground, need of repairs, absence of full force, etc.

In fact, the grading of the ore had to be almost entirely a matter of personal attention of the captain and his clerk, who must be familiar with results taken from every part of the mine, and change men about, whenever thought best, to make the necessary grades. It was found difficult to know how to obtain such mixtures, unless constantly on the ground, nor could maps embrace the irregular stopes and raises by any convenient plans and cross-sections.

With regard to the open-pit, where the ore is milled to the first level of the mine, chute samples are generally the most relied upon, though special samples are sometimes taken.

The class of ore in the various localities of the pit having been ascertained, men can be sent at any time to certain places and take out whatever grade of ore is required to mix with the grades being made.

At the Salisbury mine of the Cleveland Cliffs Company, where three or four grades of ore are made, the most reliance is put upon the skip samples, and when anything runs unusual, special stope samples are taken. The railroad cars are also sampled as well as the cargoes at the shipping port. These samples generally check very closely with each other, and are considered very satisfactory.

Lake Superior Iron Company.—At the Lake Superior Company's mines the stopes are generally sampled three times a week. Samples are usually taken by the shift-bosses in the forenoon, dried and ground in the afternoon, and the results are obtained from the laboratory by the next noon. In the regular grades of ore a daily sample is taken from the cars, which in special cases may be cut up into samples representing 10 to 40 cars. From the stockpiles, 20 to 30 cars make up a sample.

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These samples are sent in at night, and worked at convenience.

During the winter daily stockpile samples are taken and combined into a weekly sample for analysis.

In the Lake shaft of the Lake Superior Company there is a body of ore which is interesting, to the chemist at least, on account of the unusual amount of insoluble phosphorus which is present. A year ago an attempt was made to keep a daily record of the insoluble phosphorus in each stope separately, to see if there was not uniformity enough in it to warrant the addition of a constant quantity to the soluble phosphorus result. Although the main object was not attained, the results were so interesting that they were obtained for this paper. On the first, or 320-foot level, the insoluble phosphorus ranged from .002 to .031, giving an average of .007, the soluble being .051. On the 380-foot level the insoluble phosphorus ranged from .006 to .185, giving an average of .033, the soluble being .047. On the 444-foot level the insoluble ranged from .006 to .132, giving an average insoluble of .044 and soluble .051. On the 514-foot level the insoluble ranged from .006 to .078, average .023, and soluble .125.

Thus the irregularity of the ore, and the added inconvenience of high insoluble phosphorus prevented the separation into a bessemer grade, though the ore from the upper levels was put out for a .070 grade.

From all its mines the Lake Superior Company makes a total of thirteen grades of ore, six of which would be considered bessemer and seven non-bessemer, and they consider their system of sampling to be sufficiently accurate to accomplish the necessary separations.

CAMBRIA & LILLIE.—At the Cambria mine it is only found necessary to sample the stopes about every other day, and the next sample is taken from the cars, it being the rule not to exceed ten cars to the sample, whether taken from stockpile or pocket. At the Lillie mine each stope is sampled every day. Daily skip samples of each of the two grades of ore are also taken, as follows:

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A man is stationed where the tram cars dump into the skip, and it is his business to take the contract tag and a handful of ore from each car, and place the tag on a hook over the box that has that contract mentioned on its board, and put the ore in the box. There being but two grades of ore, and consequently but two boxes, and their appropriate tags, any error in taking the samples can be easily checked up at the end of each 24 hours.

In practice, the results from these daily skip samples are found to agree closely with those from the railroad cars, which latter include only 10 cars to the sample, as in the case of the Cambria ore. An additional check upon the above work is sometimes made by also taking cargo samples at the shipping port.

NEGAUNEE MINING COMPANY.—In the Negaunee mine one man does all the sampling underground. It is so arranged that each crew has two places to work in, mining from one place while the other is being sampled and analyzed, and vice versa. In this way the underground results can be of much more uniform. Every tram car of bessemer ore is then sampled and put into the daily output sample. Railroad car samples are also taken, varying in number of cars to the sample from 10 to 40.

During the winter the stockpile is sampled three times a day, and the samples combined into a daily sample.

In looking over the comparative averages of their bessemer sampling for the past month, we find an extreme difference of .3 per cent in iron and .004 per cent in phosphorus between the stope samples, tram car and railroad car samples, which plainly shows the efficiency of the method adopted.

QUEEN MINE. — Here, as at the Negaunee mine, it is sometimes customary to work the crews in two places, so that the broken ore can be sampled and analyzed before being hoisted. Where the phosphorus cuts a figure the stopes are sampled every day. If they are taken in the morning, the results are obtained the same day. Daily skip samples of each of the seven or eight grades of ore are taken and no further sampling is attempted.

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CHAMPION IRON COMPANY.—At the Champion mine but little sampling is required. The stopes are rarely sampled unless some irregularity is noticed in the output. Tape line samples of the railroad cars are taken, and combined into a daily sample of each of the three grades. The stockpile is also sampled daily.

The following table will doubtless prove of interest in connection with the general subject of sampling:

NAME	Number of Chemists and Assistants	Number of Persons Grinding Ore	Grinding Materials	Iron Method	Phosphorus Method
Pittsburg and Lake Angeline Iron Co.....	3*	2	Steel Mortar Agate Mortar	Permanganate†	Permanganate§
Cleveland-Cliffs Iron Co	2	2	Gates Crusher Rubbing Plate	Permanganate†	Permanganate§
Lake Superior Iron Co.....	3	1	Gates Crusher Chrom-Steel Plate	Permanganate†	Permanganate§
Negaunee Mining Co. and Jackson Iron Co....	2*	1	Blake Crusher Mortar Plate	Permanganate†	Alkali‡
Cambria and Lillie Mining Cos.	2*	1	Mortar Plate	Permanganate†	Permanganate§
Queen Mining Co.....	3*	1	Hammer Rubbing Plate	Permanganate†	Weigh Yellow Precipitate
Champion Iron Co.....	2*	1	Gates Crusher Plate	Permanganate†	Alkali‡

* Chief chemist also mining engineer.

† The Zimmerman-Reinhardt method, described in the Journal of the American Chemical Society, May, 1896.

§ Emmerton's method.

‡ Handy's method.

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COMPARATIVE TESTS OF BRACING FOR WOODEN BENTS.

BY PROF. EDGAR KIDWELL, MICHIGAN MINING SCHOOL.

Owing to the increasing cost of timber, and the better realization of the necessity for stricter economy in mining, the constructive details of mine buildings are now receiving much more attention than was accorded them a few years ago. Some of the mines are now extensively using cast-iron knees or angle plates, instead of the usual forms of wooden struts. As I have been unable to obtain any authoritative data as to the relative value of the different forms of bracing, and the matter is one of importance, I planned the series of experiments herein described, and the work was executed by Messrs. Elmer W. Durfee and Frederick P. Burrall, as a graduation thesis.*

GENERAL CONSIDERATIONS.

That our results might represent as nearly as possible what can be expected in actual structures, we decided to make the principal members of our bents not less than 4 x 4 inches using bracing of proportionate size.

As the office of the bracing is to add rigidity to the structure, it seemed to us that the proper method of testing the bracing was to anchor the sill of the bent securely, apply to the caps a thrust tending to rick or force the bent over in its own plane, and determine the relation between the amount of yield in the bent, and the force producing this yield. But since the stringers in trestles, and the joists or girders in buildings,

*It is intended to make further experiments in this line and I would esteem it as a favor to receive from members of the Institute and others interested criticisms and suggestions. E. K.

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serve to restrain the bents from any sidewise movement of consequence, we considered it necessary to duplicate this condition in our tests, in a manner to be shown later.

APPARATUS.*

In all the tests the stress on the bent was applied by means of a 100,000 pound Riehle testing machine, rigged as shown in Plate A. Our reason for using the two sheave blocks was to neutralize the horizontal stress on the top frame of the machine, and yet allow the tension in the rope to be indicated directly on the scale beam. By employing the two double blocks the stress, as read on the machine, was only one-half of the horizontal thrust on the bent; then by doubling the pressure shown on the beam we obtain the stress on the bent. The blocks were of iron, each containing two six-inch roller-bearing sheaves, and were furnished by the Boston and Lockport Block Company. The rope used was 1¼-inch manilla. The rear block was lashed to an eye-bolt of 1¼-inch iron, anchored through a 28-inch stone wall. A similar eye-bolt transmitted the stress from the forward tackle back to the first draw block on the frame. To hold the bents firmly in place during the test, they were enclosed in a cage or frame, shown in Plate B, Fig. 1. This was built of 4 x 4-inch white pine, except the bracing, which was of the size shown on the plate. The floor of the room where the frame stood was taken up, and two timbers, 8½ inches apart were notched one inch into the joists. Six uprights, three on a side, were mortised into these timbers and capped at the top with pieces 4 x 4-inch. This left about four inches between the caps and the ceiling. A 2 x 10-inch plank was fastened to the ceiling with lag screws and the remaining space was filled with 2x10-inch cross pieces and wedged. The top timbers were then screwed to the ceiling plank, thus holding the frame firmly in position. A second 4 x 4-inch, resting on the bottom timber, was next fitted in between the uprights. To support the bents, seven short pieces of 4 x 4-inch, 16½ inches long, were placed across the second bottom timbers and screwed firmly with ¾ x 10-inch lag screws.

* All plates and photographs are placed in order at the end of the text.

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The bent to be tested was placed in this frame and its sill was secured to the short cross pieces with $\frac{5}{8}$ x 8-inch bolts, seven in number, one for each cross piece. The top and sides of the bent were free, except that the side motion, previously referred to, was prevented by $\frac{1}{8}$-inch strips nailed to the inside of the posts of the frame, and on each side of the cap of the bent.

The cross-pieces marked B, B, B, in Plate B, Fig. 1, were used only while testing the bents marked 1A, 2A, and 3A, and served to hold the bents down, as if they were under a superimposed load. There were three of these cross pieces bolted to the uprights just above the cap of the bent, and braced by blocks nailed above them. The cross piece farthest from the machine and on the left of the plate, was mortised into the upright, since it was subjected to the greatest upward pressure. These cross pieces were well lubricated to allow the bent to move under them easily, and thus prevent an additional stress, due to friction, from being measured on the machine.

The stress was applied to the bent by means of two blocks, connected by two $\frac{1}{8}$-inch iron rods about 15 feet long, one on each side of the frame. The two blocks were of oak, $3\frac{1}{2}$ x $5\frac{5}{8}$ inches by 25 inches. The eye-bolt which transmitted the stress from the forward tackle to the first draw block passed clear through the latter, and terminated in a nut bearing on a 5-inch cast washer. By screwing up this nut, the distance from the block to the sheaves could be adjusted to suit the length of the various bents. In the center and on the inside of the rear block was fastened a square cast iron shoe (Plate B, Fig. 2), which rested against the end of the cap of the bent and prevented it from crushing. The rear ends of the $\frac{7}{8}$-inch rods were threaded for a length of 18 inches, and instead of nuts, tapped hand wheels were used for convenience in taking up any slack in the rope and for applying a small amount of stress on the bent at the beginning of the test. Plate B, Fig. 2, shows all necessary details of this arrangement.

The deflection of the bent from the perpendicular was read directly on a steel scale arranged as shown in Plate C. A strip

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of wood seven feet long nailed to a block on the cap of the bent so as to clear the rear draw block, was arranged so as to slide just over and back of a fixed steel scale. The rear end of the strip carried a brass pointer which was set at zero when there was no stress on the bent. Then, as the bent moved, the deflection could be noted by watching the pointer travel over the scale.

FORMS OF BENTS.

All the bents tested were of the same inside dimensions, i. e., 6 feet high and 6 feet between posts. They were made of 4 x 4-inch white pine taken from the same stock and were built by the same man, a professional carpenter, who was instructed to exercise equal care in making every detail of each bent. In this way we were reasonably certain of getting timbers of about the same average quality, and especially of having all joints made with the same degree of accuracy.

BENT NUMBER 1.

The cap and sill of bent No. 1 were 12 feet 8 inches long and the braces were of 2 x 4-inch white pine, having the 2-inch dimension in the plane of the bent. They were cut to a driving fit into notches in the posts, cap and sill of the bent. In each end of the braces were driven two 3½-inch No. 12 wire nails. The posts were mortised into the cap and sill, and held in place by a ½-inch oak pin at each mortise and tenon joint. For further details of this bent see Plate I.

Bent No. 1A differed from No. 1 only in the manner of testing.

BENT NUMBER 2.

This bent differed from No. 1 only in the position and method of fastening the braces. These were put with the 4-inch dimension in the plane of the bent. Tenons 1½ inches thick on the ends of the braces were let into mortises in cap, sill, and posts, and secured by ½-inch oak trenail pins. See Plate II.

Bent No. 2A differed from No. 2 only in the manner of testing.

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BENT NUMBER 3.

The cap and sill of this bent were made only 8 feet 8 inches long, as all bracing was on the inside of the posts. There were two diagonal braces of 3 x 3-inch white pine, halved together at the center and held fast at this joint by a bolt. The posts were mortised into the cap and sill as in bents Nos. 1 and 2. See Plate III.

Bent No. 3A differed from No. 3 only in the manner of testing.

BENT NUMBER 4.

This bent was the first of the set braced with iron knees or shoes. The cap and sill were each 9 feet 2 inches long. The eight corners of the bent were braced with cast iron knees or shoes, each of which was held in place by eight $\frac{3}{8}$ x $5\frac{1}{2}$-inch bolts. See Plate IV, Fig. 2. The posts of the bent were butted square against the cap and sill, no fastening being used other than that afforded by the bolts through the shoes. For further details of this bent see Plate IV.

BENT NUMBER 5.

This bent differed from the preceding one only in the shape of the knees, the latter having a $\frac{1}{2}$ x $\frac{1}{2}$-inch cog or lug at each end, as shown in Plate V, Fig. 2. Plate V gives a drawing of the entire bent.

BENT NUMBER 6.

Plate VI shows detail drawing of this bent. It differs from the preceding one only in the position of the cog on the shoe, which, in this case, is placed in the center of the leg of the angle, as shown in Plate VI, Fig. 2.

BENT NUMRER 7.

The leading feature of this bent is the form of its brace, which so far as we know has not hitherto been used for wooden bents. It is evident that the resisting leverage of the knees in bents Nos. 4, 5 and 6, is very much less than that of braces in Nos. 1 and 2 increases the liability of loosening up

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through shrinkage. The form of brace used in this bent, and shown in detail in Plate VII A, was therefore designed with the idea of securing all the advantages of the forms of bracing in Nos. 1 and 2 without the disadvantages due to shrinkage. It may be urged that the end shrinkage of wood is but trifling, but against this view we can say that while the shrinkage endwise of green timber, such as is usually used about mines, is more than usually supposed, yet the side shrinkage of the caps, sills, and posts, adds its effect, so that the joints inevitably get slack after the structure has been in use a year or more. The braces can be wedged up tight from time to time, but this is seldom done, owing to the trouble and expense. The form of brace used in bent No. 7 could easily be set up tight by driving in the spikes, or turning up the nuts if the brace be bolted as in bent No. 7A.

In bent No. 7 the braces were held in place by two 3-inch railroad spikes driven at each end, as in Plate VII., and slipping along the timbers was prevented by a $\frac{3}{8}$ x $\frac{3}{8}$-inch cog let into the timber. The posts were fastened to the cap and sill by $\frac{3}{8}$ x $5\frac{1}{2}$-inch bolts two at each joint. They passed clear through the cap and sill, and screwed into nuts boxed into posts, as in Plate VII.

BENT NUMBER 7A.

This differed from No. 7 in two ways: (1) The joint between posts and cap and sill was secured by a $\frac{5}{8}$ x 8-inch lag screw, instead of by bolts. (2) The railroad spikes were reinforced by $\frac{3}{8}$ x $5\frac{1}{2}$-inch bolts, two in each foot of the brace. The holes for these bolts were drilled, while holes for bolts in all other knees were cored.

It will be seen that most forms of bracing in common use have been included in the tests. That in bent No. 2 is by far the most common, being used in almost all kinds of framed structures. The form of bracing in bent No. 1 has been but little used, the stamp mill at the Huron Copper Mine and a shaft house and stamp mill at the Centennial Copper Mine being the most prominent examples of this construction in the copper region. The form evidently has advantages over the

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preceding one, in point of cheapness in execution and ease with which it can be wedged up tight when loosened by shrinkage. But the most important point in its favor is that at the beginning it can be made to a tight driving fit, giving the bent a rigidity which can hardly be got with the bracing in bent No. 2, no matter how it be put in.

The form of bracing in No. 3 has been much used in the mining districts of Lake Superior. It is evidently subject to all the troubles from shrinkage noted against the other two forms, the greater length of bracing causing even greater troubles from shrinkage.

To avoid the evils due to the shrinkage of the braces, the iron knees were introduced some years ago, and are now extensively used at the Calumet and Hecla, and the Tamarack mines. The form employed in bent No. 6 is the one most commonly used. These knees can be quickly tightened up by a few turns of the nuts, and have the further advantage of durability and can be used over and over again when buildings are torn down, or repaired.

The form in No. 7 and No. 7A has been sufficiently discussed when describing the bents.

METHODS OF MAKING THE TESTS.

The sill of the bent was anchored firmly in place, then the testing appliances, as shown in Plates A to C were attached. The pointer on the scale, Plate C, was set at zero, and the test started. From Plate A it is evident that as the cross-head of the machine descends, the rope applies the stress to the first draw block, which transmits it in turn to the two iron rods running to the rear draw block, Plates B and C. The rear draw block then throws the stress in form of a thrust on the end of the cap of the bent, as is obvious from Plates B and C, also photographs of bents No. 3A and No. 4. But evidently a stress which could be weighed on the testing machine, could be put on the bent by turning up the hand wheels shown in Plate B, and in our tests the stress was always applied by these wheels at the beginning, till the ropes were drawn up taut, otherwise the range of movement in the cross-head of the

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testing machine would have been insufficient to carry the test to completion. One observer stood at the machine, and another at the device for measuring deflections. For every eighth of an inch of deflection, readings of the stress were taken, in the following manner. Electric signal bells were set up, and just before the pointer reached the $\frac{1}{8}$-inch marks, a signal was given, and the operator at the machine then changed the speed to the slowest obtainable. When the pointer was exactly on the $\frac{1}{8}$-inch mark the proper signal was given, the machine was instantly brought to rest and the stress shown on the beam recorded.

At the beginning of our work, we intended to test all bents without in any way applying a vertical restraining force on the cap. But tests on Nos. 1, 2, and 3, showed that the braces in compression, by turning in the lower joint like a hinge, formed a sort of toggle with the cap (or post in case of lower braces), and forced the latter upwards. In most cases in an actual building there would be sufficient superimposed load to prevent this upward motion of the caps and posts, hence we built three more bents marked as Nos. 1A, 2A, and 3A, and when testing these, the upward motion was prevented by the pieces B, B, B, Plate B. We did not consider it at the time necessary to apply this method to the other forms, but it now seems that it would have been better to have tried it on bents like Nos. 7 and 7A.

The accompanying photographs were taken immediately after the tests were stopped, and show more clearly than a verbal description the manner in which the bents failed.

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RECORD OF TESTS.

Bent No. 1.

Deflections, Unit, ⅛ inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
1	240	480	
2	320	640	
3	410	820	
4	850	1700	
5	990	1980	
6	1070	2140	
7	1220	2440	
8	1290	2580	
9	1410	2820	
10	1220	2440	—Began to crack at
11	1380	2760	top of far post.
12	1400	2800	
13	1470	2940	
14	1330	2660	
15	1530	3060	—Began to pull out
16	1530	3060	at bottom of far
17	1040	2080	post, and slight-
18	1070	2140	ly at bottom of
19	1140	2280	near post.
20	1150	2300	
21	1150	2300	
22	1270	2540	
23	1270	2540	
24	1270	2540	—Broke and went to pieces. See photograph No. 1.

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Bent No. 1A.

Top blocks of testing frame were in, so the bent was held down.

Deflections, Unit, 1/8 inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
1	60	120	
2	90	180	
3	180	360	
4	400	800	
5	1060	2120	
6	1450	2900	
7	1780	3560	
8	2100	4200	
9	2430	4860	
10	2600	5200	
11	2910	5820	
12	2990	5980	
13	3180	6360	
14	3370	6740	—Top timber broke in two places where the braces were notched, and bent yielded 5/8 inch. See photograph No. 1A.
15			
16			
17			
18			
19	2030	4060	
20	1980	3960	
21	2040	4080	
22	1970	3940	
23	1900	3800	
24	2020	4040	
25	2110	4220	
26	1970	3940	
27	1800	3600	
28	1670	3340	
29	1820	3640	
30	1820	3640	
31	1820	3640	
32	1770	3540	

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Bent No. 2.

Deflections, Unit, 1/8 inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
1	80	160	
2	160	320	
3	210	420	
4	680	1360	
5	840	1680	
6	950	1900	
7	980	1960	
8	1000	2000	
9	1090	2180	
10	1180	2360	—Sheared top pin in
11	1200	2400	far end.
12	1200	2400	
13	1200	2400	
14	1210	2420	—Sheared out two
15	1240	2480	pins in tension
16	1240	2480	braces at far
17	1240	2480	end. Both bot-
18	1230	2460	tom pins shear-
19	1240	2480	ed out. See pho-
20	1240	2480	tograph No. 2.
21	1240	2480	
22	1140	2280	
23	1160	2320	
24	1150	2300	
25	960	1920	
26	960	1920	
27	910	1820	
28	900	1800	
29	870	1740	
30	870	1740	
31	840	1680	
32	840	1680	
33	840	1680	

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Bent No 2A.

This bent was held down by the top blocks of the testing frame.

Deflections, Unit, ⅛ inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
1	160	320	
2	280	560	
3	900	1800	
4	1150	2300	
5	1400	2800	
6	1700	3400	
7	2000	4000	
8	2350	4700	
9	2630	5260	
10	2920	5840	
11	3090	6180	
12	3260	6520	—Far post cracked
13	3440	6880	at place where
14	3680	7360	lower braces were pinned.
15	3760	7520	—Ditto, near post.
16	4000	8000	—Both posts cracked off at upper and lower bracing pins. See photograph No. 2A.

Bent No. 3.

Deflections, Unit, ⅛ inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
1	160	320	
2	250	500	
3	470	940	
4	480	960	—Bottom of far post
5	510	1020	began to pull out.

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Bent No. 3—Continued.

Deflections, Unit, ⅛ inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
6	520	1040	
7	520	1040	
8	520	1040	
9	520	1040	—Bottom of far post pulled out entirely.

Bent No. 3A.

Deflections, Unit, ⅛ inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
1	200	400	
2	360	720	
3	400	800	
4	1370	2740	
5	1830	3660	—Tension brace loosened.
6	2050	4100	
7	2200	4400	
8	2380	4760	
9	2450	4900	
10			—Tenon at top of far post sheared off.
11	1950	3900	
12	1950	3900	
13	1710	3420	
14	1650	3300	
15	1670	3340	
16	1650	3300	
17	1660	3320	
18	1650	3300	—Lower tenon on near post sheared off.
19	1600	3200	
20	1620	3240	
21	1640	3280	
22	1630	3260	
23	1750	3500	
24	1740	3480	

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Bent No. 3A—Continued.

Deflections, Unit, ⅛ inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
25	1480	2960	
26	1350	2700	
27	1350	2700	
28	1350	2700	
29	1460	2920	—Upper tenon of far post sheared off, and top timber slid on far post. See photograph No. 3A.

Bent No. 4.

Deflections, Unit, ⅛ inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
1	40	80	
2	110	220	
3	80	160	
4	180	360	
5	210	420	
6	240	480	
7	590	1180	
8	600	1200	
9	670	1340	
10	740	1480	
11	800	1600	
12	880	1760	
13	950	1900	
14	1000	2000	
15	1050	2100	
16	1160	2320	
17	1200	2400	
18	1240	2480	
19	1300	2600	
20	1390	2780	—Began to shear at

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Bent No. 4—Continued.

Deflecrions, Unit, 1/8 inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
21	1400	2800	bottom of far
22	1460	2920	post.
23	1470	2940	
24	1540	3080	
25	1640	3280	
26	1650	3300	
27	1690	3380	
28	1660	3320	—Broke web of shoe
29	1730	3460	at bottom of
30	1750	3500	near post, side
31	1720	3440	next to draw-
32	1660	3320	head. Broke
33	1730	3460	web of near
34	1750	3500	shoe at top of
35	1750	3500	far.
36	1750	3500	
37	1710	3420	
37	1740	3480	
39	1720	3440	
40	1750	3500	
41	1760	3520	
42	1760	3520	
43	1760	3520	
44	1780	3560	—Far shoe at bottom
45	1790	3580	of post broke.
46	1620	3240	
47	1670	3340	
48	1670	3340	
49	1700	3400	
50	1720	3440	
51	1730	3460	
52	1780	3560	
53	1790	3580	
54	1790	3580	
55	1820	3640	

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Bent No. 4—Continued.

Deflections, Unit, 1/8 inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
56	1820	3640	
57	1760	3520	
58	1780	3560	
59	1840	3680	
60	1870	3740	
61	1880	3760	
62	1890	3780	
63	1890	3780	
64	1770	3540	
65	1680	3360	
66	1720	3440	—Near post broke off at bottom of top shoe. See photograph No. 4.

Bent No. 5.

Deflections, Unit, 1/8 inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
1	0	0	
2	70	140	
3	80	160	
4	120	240	
5	130	260	
6	160	320	
7	160	320	
8	320	640	
9	330	660	
10	360	720	
11	380	760	
12	400	800	
13	710	1420	
14	770	1540	
15	920	1840	
16	920	1840	

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Bent No. 5—Continued.

Deflections, Unit, 1/8 inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
17	960	1920	
18	980	1960	
19	1020	2040	
20	1040	2080	
21	1050	2100	—Bottom of both
22	1110	2220	posts cracked at
23	1120	2240	the shoe lugs.
24	1170	2340	
25	1200	2400	
26	1210	2420	
27	1290	2580	—Far post broke at top and bottom where lugs were let in. See photograph No. 5.

Bent No. 6.

Deflections, Unit, 1/8 inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
1	0	0	
2	90	180	
3	100	200	
4	170	240	
5	240	480	
6	240	480	
7	250	500	
8	280	560	
9	520	1040	
10	600	1200	
11	670	1340	
12	730	1460	
13	800	1600	
14	800	1600	
15	880	1760	

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Bent No. 6—Continued.

Deflections, Unit, 1/8 inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
16	920	1840	
17	950	1900	
18	1010	2020	
19	1080	2160	
20	1130	2260	
21	1180	2360	
22	1200	2400	
23	1220	2440	
24	1230	2460	
25	1280	2560	
26	1290	2580	—Started to split
27	1320	2640	down the far
28	1400	2800	post at the lug
29	1440	2880	of the inside up-
30	1450	2900	per shoe
31	1510	3020	
32	1530	3060	
33	1550	3100	
34	1550	3100	
35	1620	3240	
36	1630	3260	—Top piece over in-
37	1630	3260	side shoe of near
38	1630	3260	post began to
39	1640	3280	split.
40	1640	3280	—Lug on inside shoe
41	1630	3260	of near post sheared off under it.
42	1400	2800	—Inside upper shoe
43	1500	3000	of far post broke
44	1520	3040	off just below the
45	1550	3100	lug.
46	1570	3140	
47	1580	3160	
48	1590	3180	

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Bent No. 6—Continued.

Deflections, Unit, 1/8 inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
49	1610	3220	—Top timber broke
50			just at inside
51	1240	2480	edge of inside
52	1260	2520	shoe of near post.
53	1270	2540	
54	1280	2560	
55	1310	2620	
56	1320	2640	
57	1320	2640	
58	1340	2680	
59	1340	2680	
60	1350	2700	
61	1370	2740	—Lower inside shoe
62	1080	2160	of near post broke off just above the lug.
63	1120	2240	—Far post broke off at bottom of shoes. See photograph No. 6.

Bent No. 7.

Deflections, Unit, 1/8 inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
1	60	120	
2	130	260	
3	150	300	
4	310	620	
5	350	700	
6	380	760	
7	380	760	
8	400	800	
9	1150	2300	
10	1320	2640	
11	1460	2920	
12	1570	3140	

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Bent No. 7—Continued.

Deflections, Unit, ⅛ inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
13	1600	3200	—Bottom of far post pulled out and spikes holding far bottom brace of far post pulled out at bottom. See photograph No. 7.
14			
15			
16			
17	1050	2100	
18	1080	2160	
19	1150	2300	
20	1120	2240	

Bent No. 7A.

Deflections, Unit, ⅛ inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
1	60	120	
2	200	400	
3	520	1040	
4	790	1580	
5	970	1940	
6	1140	2280	
7	1280	2560	
8	1400	2800	
9	1550	3100	
10	1670	3340	
11	1780	3560	
12	1900	3800	
13	1960	3920	
14	2180	4360	
15	2200	4400	—Far post broke off at lugs of top braces and cracked from bottom up to lugs on lower braces.
16			
17	1520	3040	
18	1630	3260	
19	1720	3440	
20	1880	3760	
21	1850	3700	—Near post cracked at bottom.
22	1870	3740	

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Bent No. 7A—Continued.

Deflections, Unit, ⅛ inch.	Pounds on the Machine.	Pounds on the Bent.	REMARKS.
23	1900	3800	—Went to pieces. Only one brace was broken, and that by the recoil of the bent when it gave way. See photograph No. 7A.

INTERPRETATION OF RESULTS OF THE TESTS.

In interpreting the results just obtained, we shall naturally compare as members of one group all those bents not restrained at the top, and consider as another group those so restrained. To permit an easier comparison of the results of the tests, they have all been plotted, giving the curves shown in Diagram I. These indicate at a glance, that in the main, those bents showing the greatest rigidity also exhibited the greatest strength. The most important part of the curves is that lying between zero and 1-inch deflection, since a greater deflection than that in a bent of the size we used, would be a sufficient reason for condemning a structure. The following table shows the stress in each bent corresponding to each ⅛-inch deflection up to 1½ inches.

Pounds Stress on the Bent.

No.	1	1A	2	2A	3	3A
1	480	120	160	320	320	400
2	640	180	320	560	500	720
3	820	360	420	1800	940	800
4	1700	800	1360	2300	960	2740
5	1980	2120	1680	2800	1020	3660
6	2140	2900	1900	3400	1040	4100
7	2440	3560	1960	4000	1040	4400
8	2580	4200	2000	4700	1040	4760

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Pounds Stress on the Bent—Continued.

9	2820	4860	2180	5260	1040	4900
10	2440	5200	2360	5840	failed	....
11	2760	5820	2400	6180	....	3900
12	2800	5980	2400	6520	....	3900

No.	4	5	6	7	7A
1	80	0	0	120	120
2	220	140	180	260	400
3	160	160	200	300	1040
4	360	240	340	620	1580
5	420	260	480	700	1940
6	480	320	480	760	2280
7	1180	320	500	760	2560
8	1200	640	560	800	2800
9	1340	660	1040	2300	3100
10	1480	720	1200	2640	3340
11	1600	760	1340	2920	3560
12	1760	800	1460	3140	3800

These are plotted to a larger scale in Diagram II.

Comparing Nos. 1, 2, and 3 it is evident that No. 1 was by far the most rigid, justifying our statement that braces as in No. 2 cannot be made as tight at the beginning as those in No. 1. No. 3 lead off well, but soon showed up poorly, because the brace when under stress forced off the cap. When restrained on top, as in No. 3A, it showed a better result. It was rigid from the start, and up to 1-inch deflection, it stood as well as any bent tested.

Nos. 1A and 2A both showed an extraordinary increase in strength over Nos. 1 and 2, though No. 1A does not make a favorable showing until it has deflected about ¾ inch,—a result due, no doubt, to failure to drive the braces in tight when erecting the bent, since No. 1A should, other things being equal, have shown a greater rigidity than No. 1, as restraining it on top could only add to its strength.

Inspection of the curves and the table shows that Nos. 1A, 2A and 3A gave greater ultimate strengths, also greater rigidity, than any of the bents with iron braces, though No. 7A

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would probably have shown up as well as any of these three had it been tested under similar conditions. It therefore appears that, when new and under conditions in average practice, the wooden braces are fully equal in rigidity and strength to any form of iron braces now in use. The strength of a structure in which wooden braces are used will not be much affected when the braces shrink, since a slight distortion of the building will bring them into play again; but the shrinkage will certainly destroy the rigidity of the structure, and it is this fact which has caused some of the mines of Lake Superior to abandon the wooden braces for iron ones. Had our time permitted we would have built a duplicate set of bents, allowed them to season for a year, then put them under test, to determine exactly what the effect of a year's shrinkage would be, and it is the intention to do this when the investigation is taken up again.

Considering the results obtained from Nos. 4, 5, and 6, which were braced with iron knees, it is evident that all these bents were far less rigid than Nos. 1, 2, and 3. No. 5 was decidedly weaker than No. 1, and only 100 pounds stronger than No. 2. Nos. 4 and 6 both exceed Nos. 1 and 2, in ultimate strength, but do not develop much strength until they are deflected far beyond anything that could be tolerated in practice. The experiments, therefore, seem to indicate that for deflections within any reasonable limit, the wooden-braced bents are the better, and if restrained or loaded on top, they will exceed in rigidity, and probably in strength, the bents braced with iron knees of the usual pattern. It may be objected against this view that had Nos. 4, 5, and 6 been restrained at the top like Nos. 1A, 2A, and 3A, they would have shown greater strength and rigidity, but we think that there would have been very little difference, since in every case the knees broke before the timbers showed any signs of serious weakening, and evidently this failure of the knees was due to cross-breaking stress caused by swinging of the parts around the joint in sill and cap, which swinging action would in no way be prevented by restraining the bent at the top. So far, therefore, the advantage appears to be on the side of the wooden braces, but

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further investigation on bents that have been allowed to season thoroughly, might show sufficient deterioration through shrinkage to give the advantage to the iron knees.

Inspection of the curves shows that No. 6, the form mostly used, is inferior both in rigidity and strength to No. 5, which was without cogs or lugs. The latter have been put in with the object of giving the knee a firm hold on the timber, but when we consider that but few workmen will take care to make a close fit, it is evident that these lugs do little more than weaken the timbers without contributing any strength. Certainly the curve for No. 5 supports this view. Hence it appears that it would be better practice to abandon the lugs, save thereby the extra metal and the fitting, and use the plain knees.

From the preceding discussion it will be evident that No. 7 was subject to the toggle-joint action between the brace and the cap, and brace and post, tending to force up the cap and post. Photograph of No. 7 shows that this was so. Still this bent within any allowable limits of deflection was superior to Nos. 5 and 6, and most of the time exceeded No. 4. In ultimate strength it exceeded No. 5, almost equaled No. 6, the usual form, and was not much inferior to No. 4. Considering both rigidity and strength we should rank this bent superior to Nos. 4, 5, and 6, though it was secured merely by two spikes at each end, and could be attached in about one-fifth of the time required to put on the others. It is possible, however, that spiking the braces to the timbers might be insufficient in a structure subject to shocks from machinery, dumping of rock, etc., as the spikes might gradually work loose. This can only be determined by actual trial under working conditions.

No. 7 shows from the start greater rigidity than Nos. 4, 5, and 6; compares very favorably with Nos. 1 and 2 at the beginning, and later exceeds either of them in strength.

It will be noticed from the photograph that failure of the bent was due to splitting of a defective post, not to any weakening of the braces. We now think that this form of brace could be improved by cutting the cog on the opposite edge of the brace foot, so as to leave the timber full size where it re-

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ceives the greatest stress. As the general construction of this bent was similar to Nos. 1 and 2, it cannot be doubted that had it been tested with the top restrained as in case of Nos. 1A, 2A and 3A, the result would have been equal if not superior to anything obtained from these bents. This point will be fully investigated later.

It therefore appears that the brace in No. 7 and 7A makes the best showing, if we take into account the unavoidable shrinkage in wooden braces. It has the further advantage of being the quickest to put in place. It excels the iron knees, since it is free from the cross-breaking stresses which caused the failure of many of the knees during the tests. These braces weighed 11 pounds each, while the knees weighed only 6.1 pounds, hence the braces will certainly cost more than the other forms. We believe, however, that it is possible so to design this form that it will cost little more than the others, and that this difference will be more than balanced by the ease with which it can be put in place.

SUMMARY OF CONCLUSIONS.

1. Form in Bent No. 1 can be made tighter on the start than No. 2, but the latter has the greater ultimate strength.

2. No. 3 is a rigid form if the forces tending to distort it are very moderate, but it cannot stand heavy stresses.

3. No. 3 is a rigid form under moderate loads but cannot stand heavy loading.

3. Nos. 1, 2, and 3 show gerater strength and rigidity accordingly as they are more heavily loaded on top.

4. No form of iron knee tested gave a very rigid bent, as the latter had to be deflected more than could be allowed in practice, before the bents exhibited much strength.

5. If iron knees are used, it is better to use the plain pat tern, instead of the usual form provided with lugs or cogs.

6. The brace in No. 7 gives a more rigid structure than any of the iron knees, and when merely spiked on is strong enough for any structure not subject to heavy shocks.

7. This brace when reinforced with bolts is probably better than any form now in use, as evidenced by test on 7A.

8. There are reasons to believe that this brace can be so designed that, apart from its greater efficiency, it will in the end be as cheap as the iron knees.

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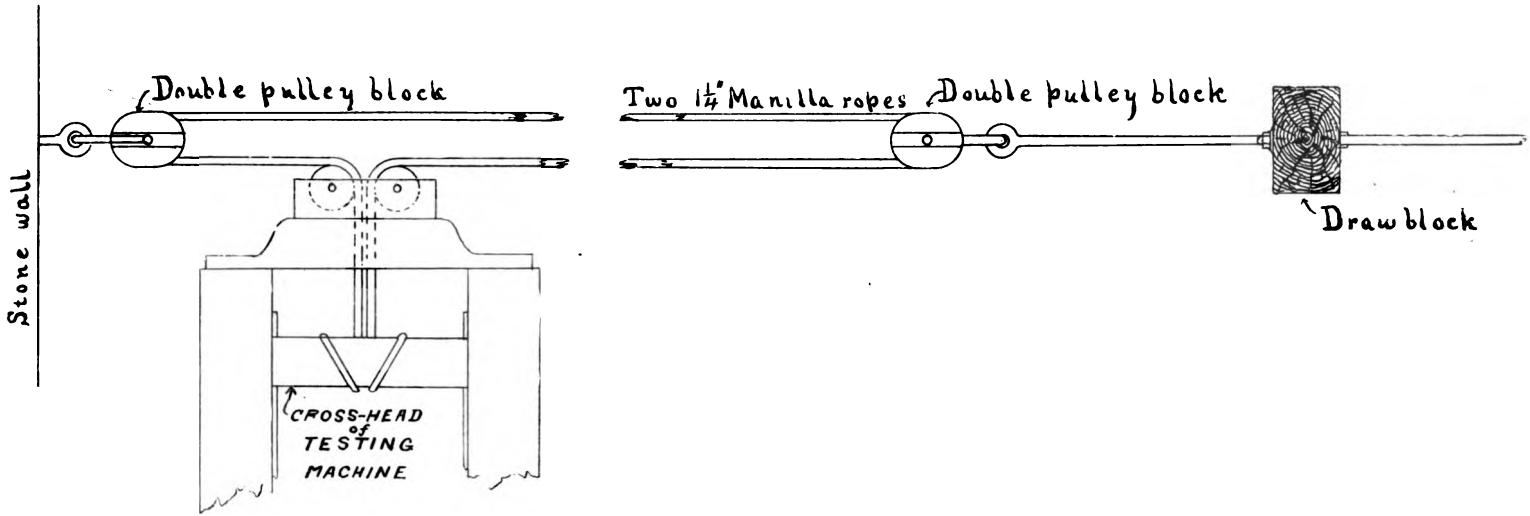

Arrangement for applying stress.

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PLATE C.

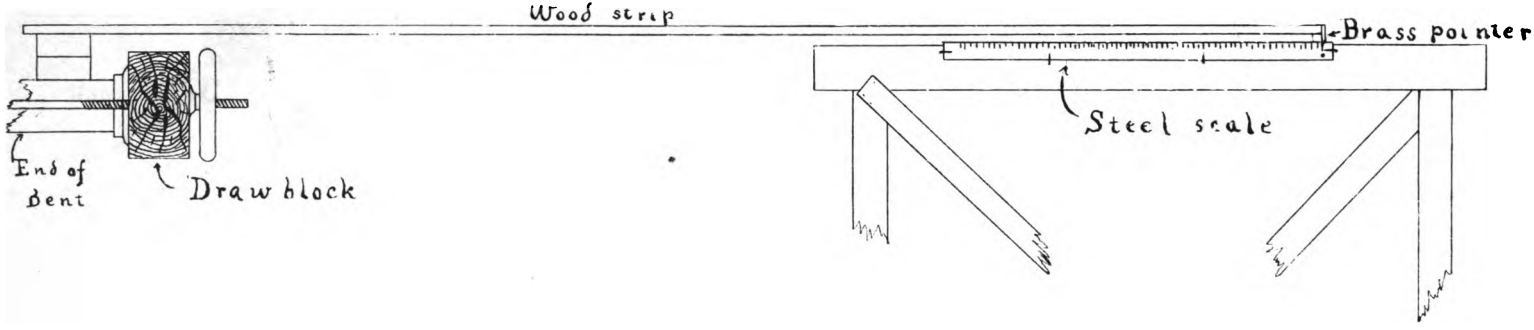

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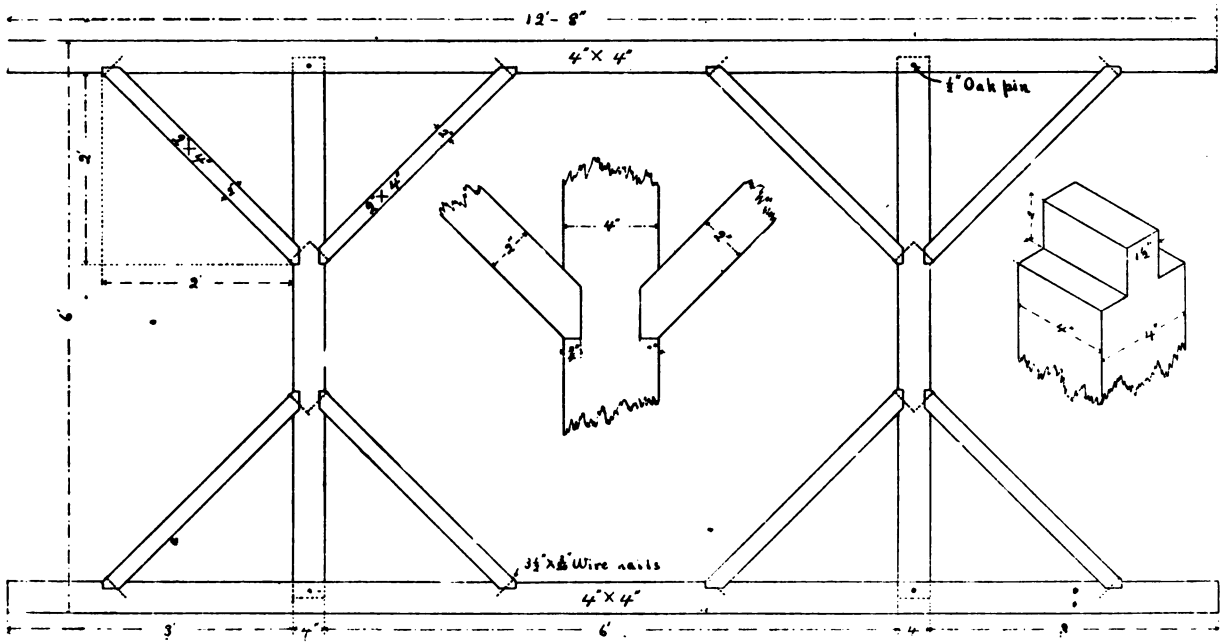
PLATE 1



BENT NO. 1.

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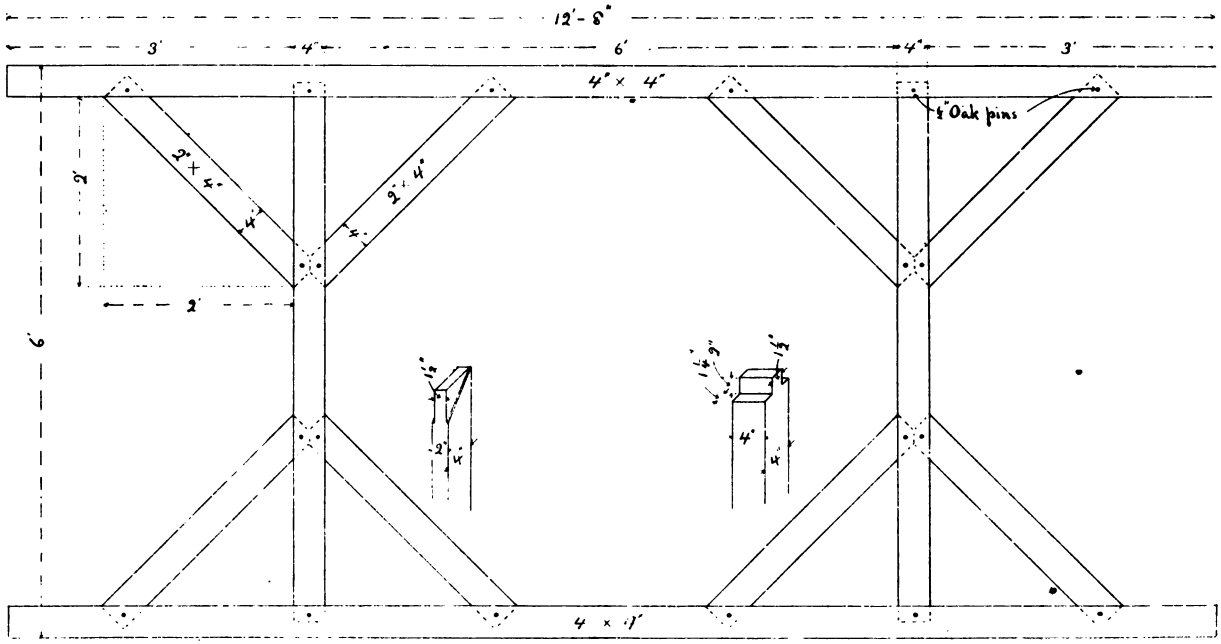
PLATE II.



BENT NO. 2

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PLATE III.

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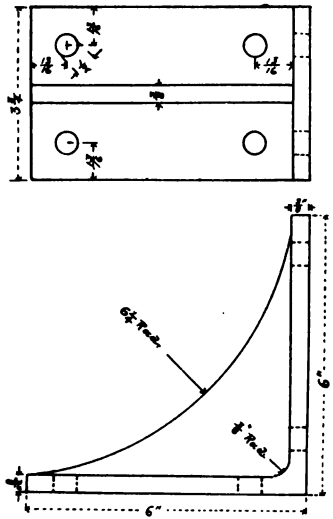

FIG 2 DETAILS OF CAST IRON BRACE FOR BENT No 4

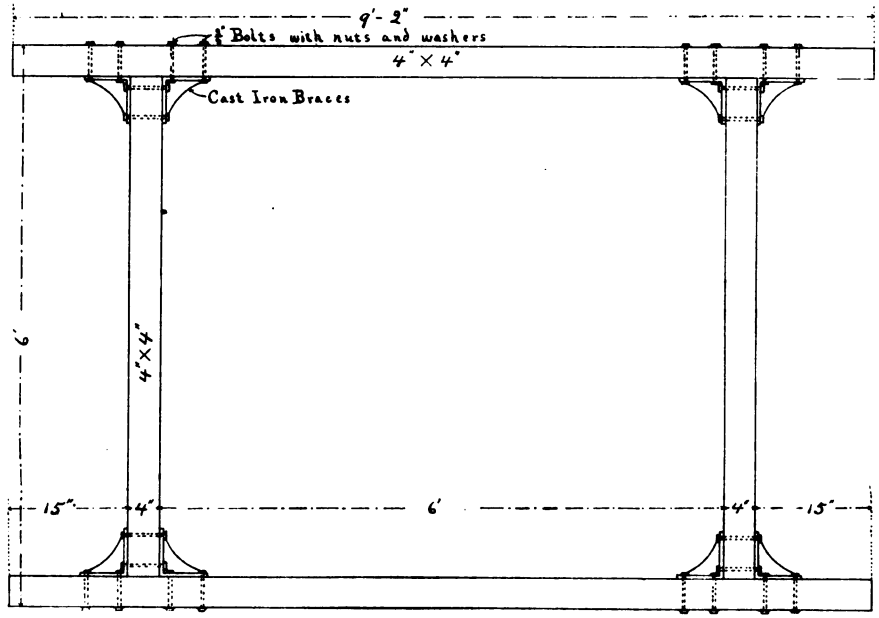

FIG1 BENT NO. 4

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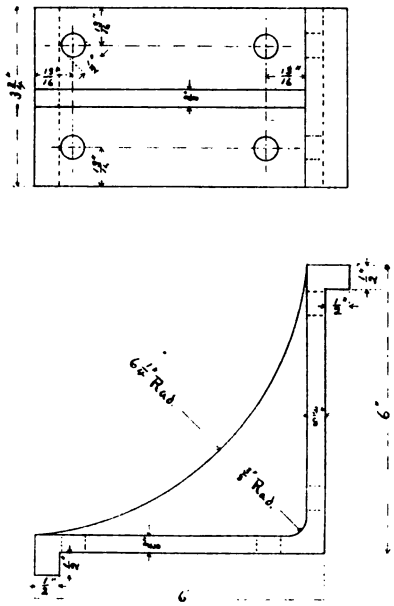

Fig. 2. Details of cast iron brace for bent No. 5.

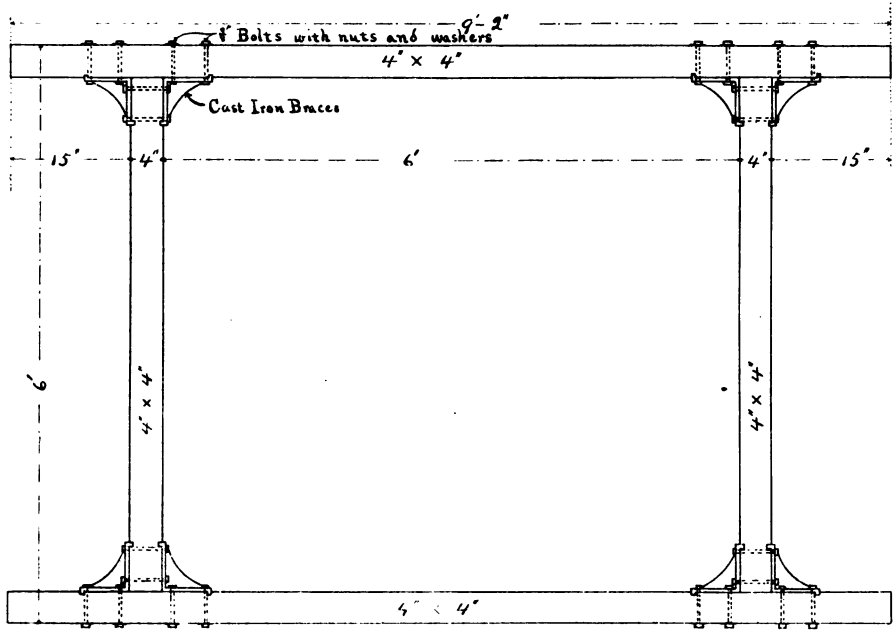

FIG. 1. BENT NO. 5.

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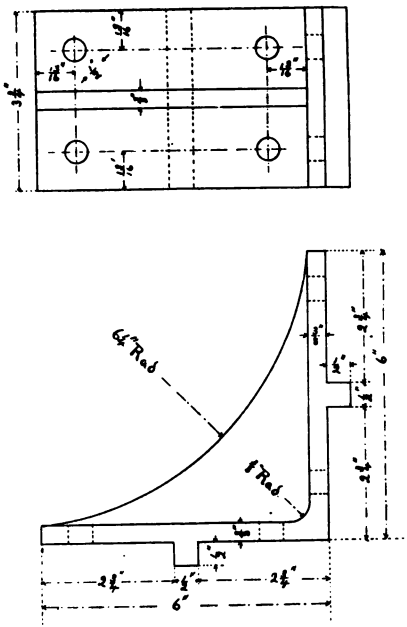

Fig 2. Details of cast iron brace for bent No. 6.

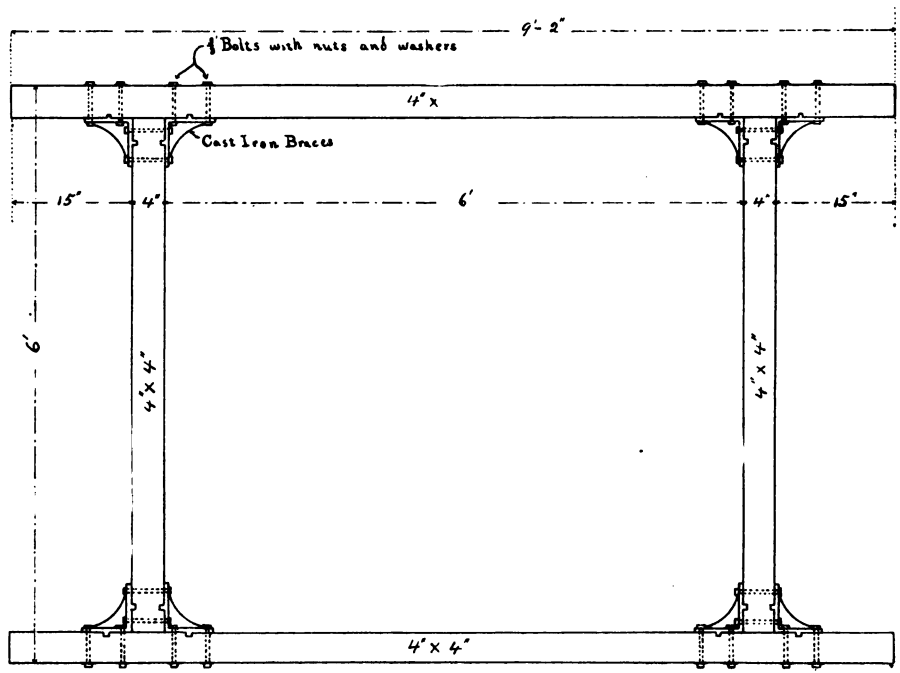

FIG.1 BENT NO. 6,

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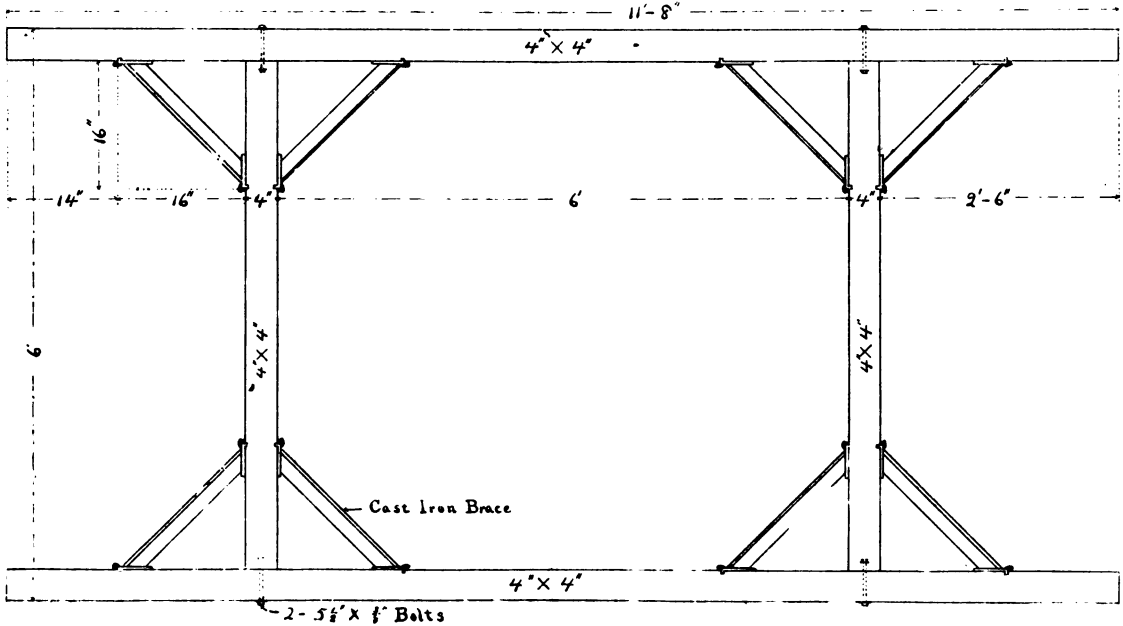

BENT NO. 7.

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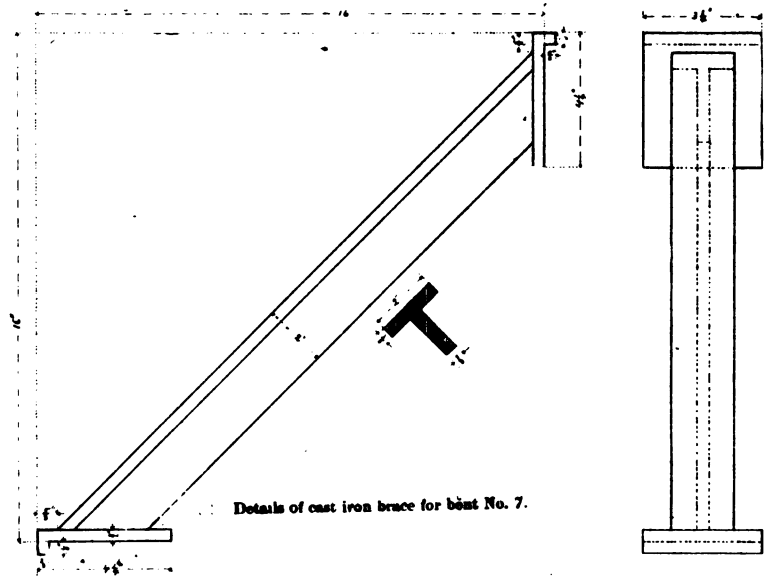
PLATE VII A.



Details of cast iron brace for bent No. 7.

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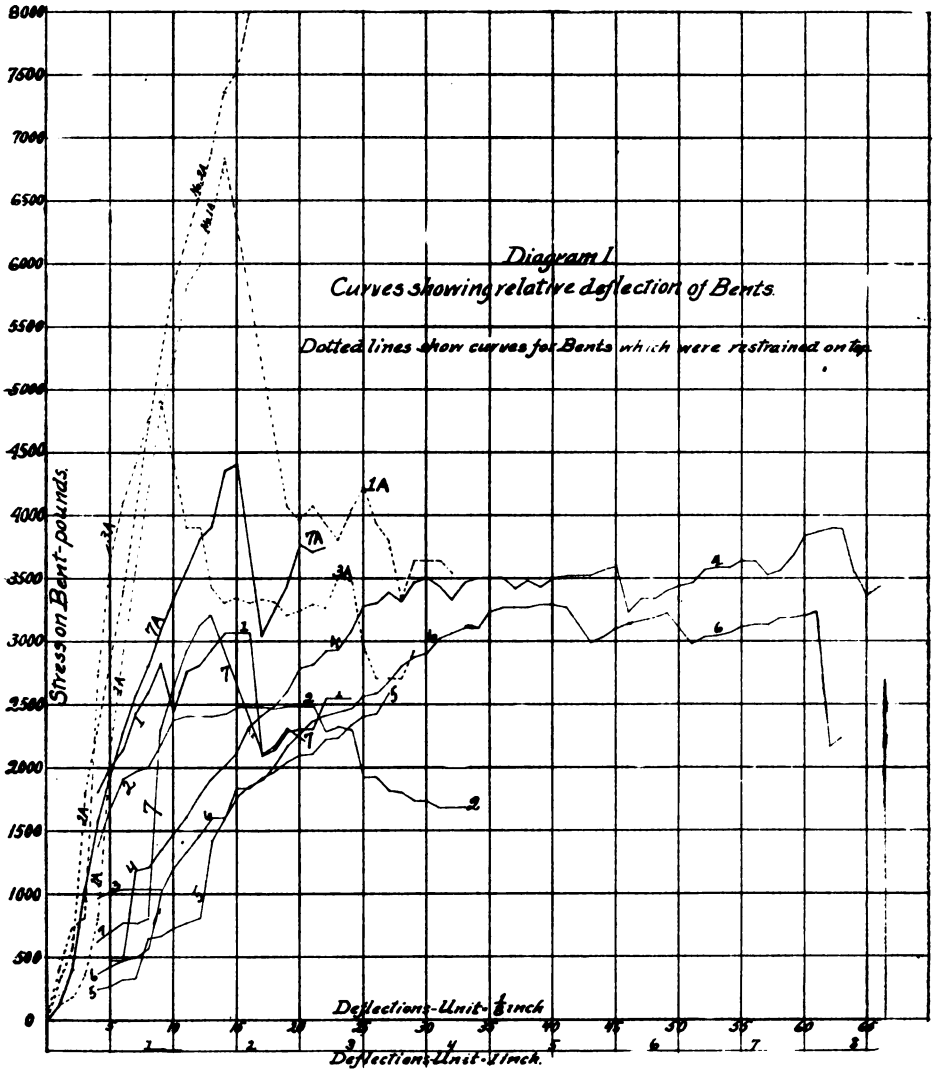
Diagram I.
Curves showing relative deflection of Bents.
Dotted lines show curves for Bents which were restrained on top.
Stress on Bent-pounds.
Deflections-Unit-1/8 inch
Deflections-Unit-1 inch.

DIAGRAM I.

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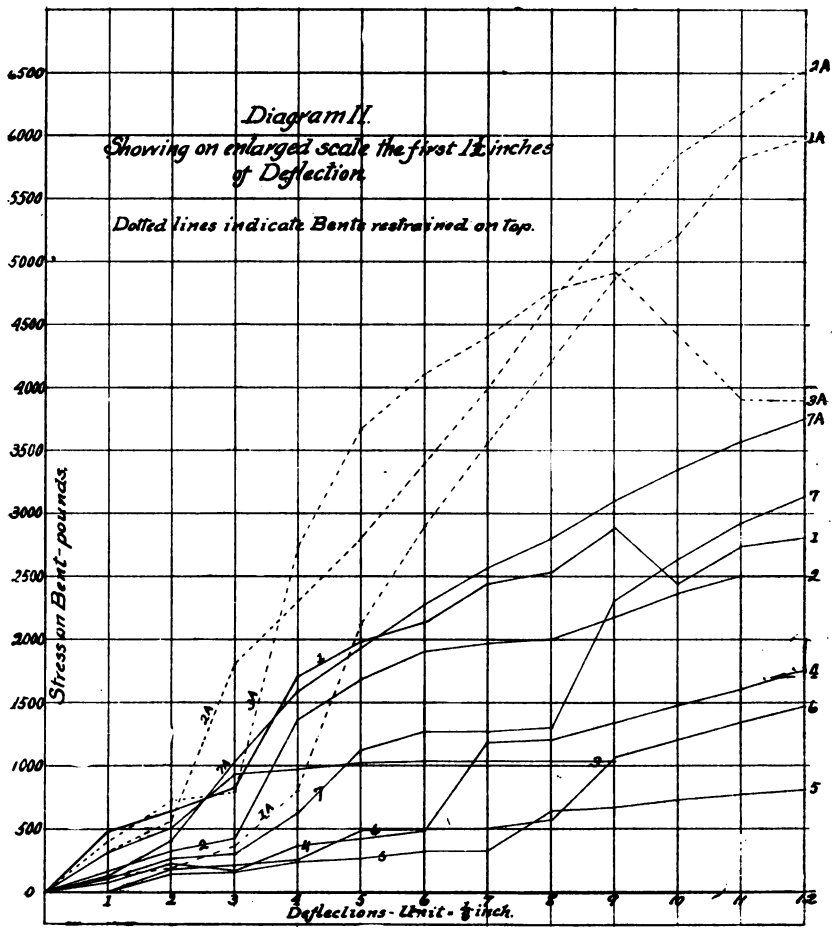

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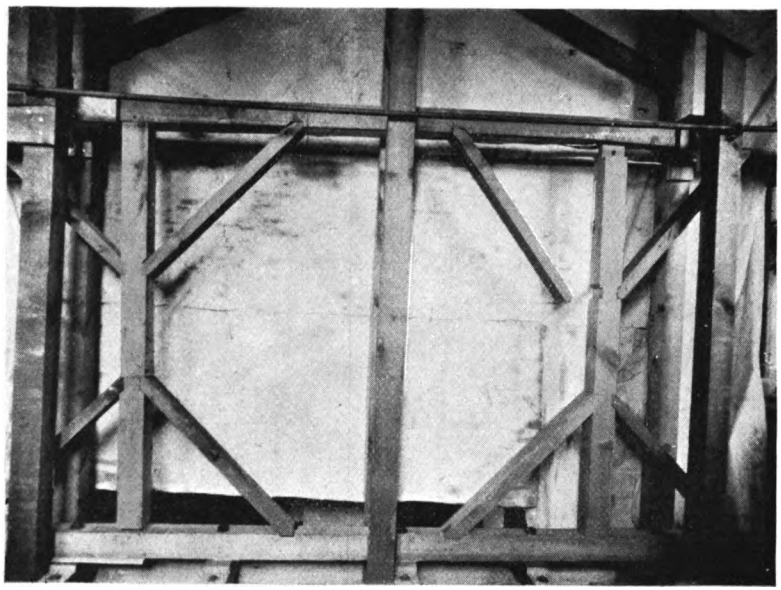

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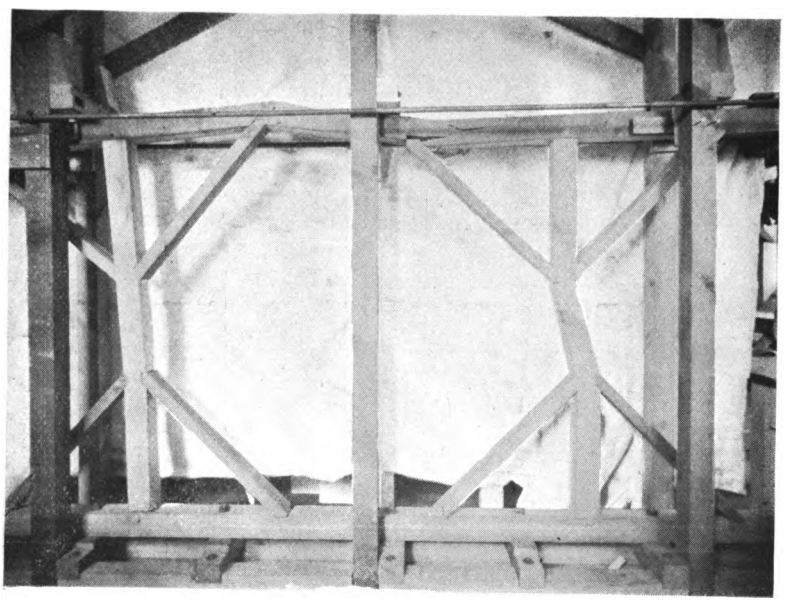

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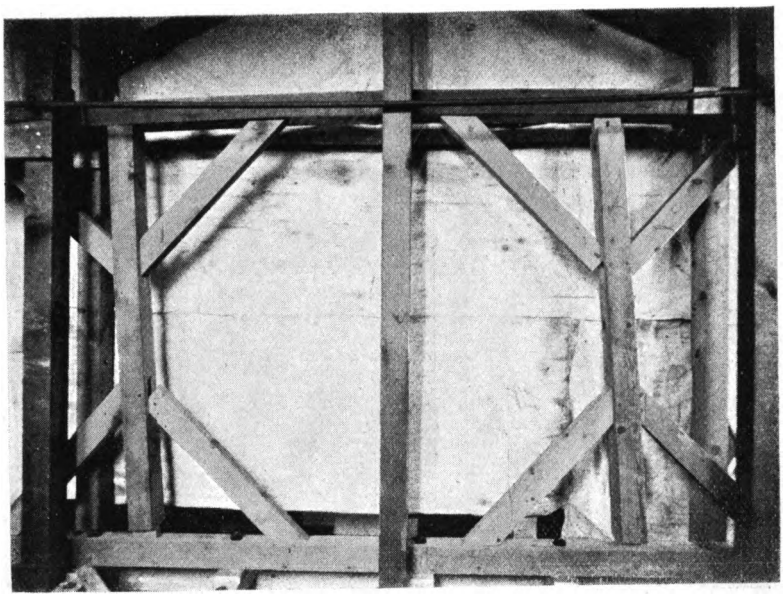

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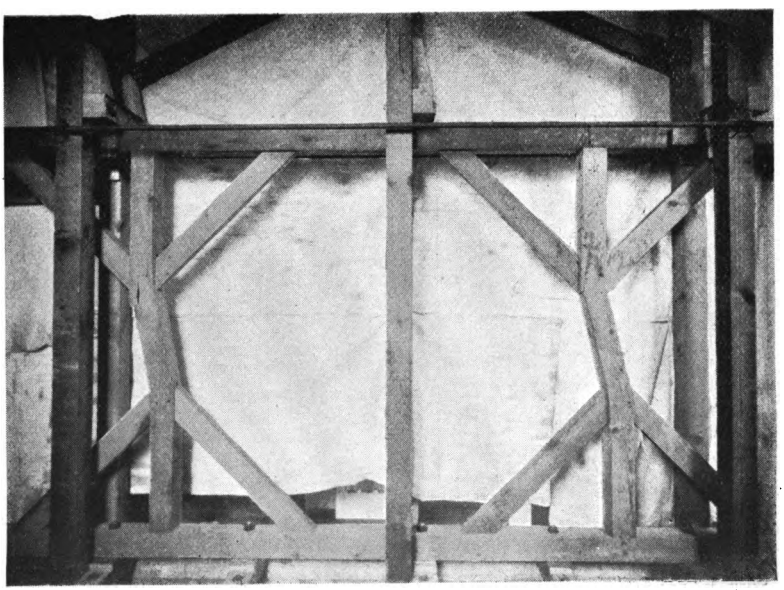

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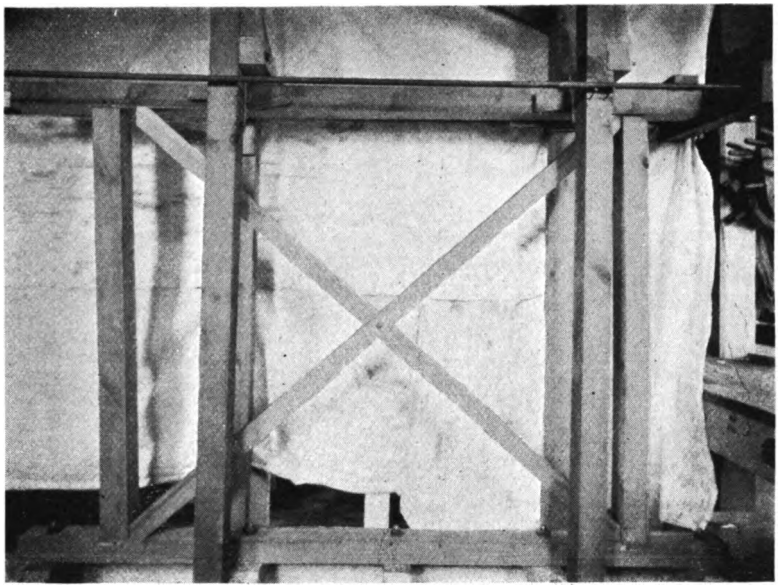

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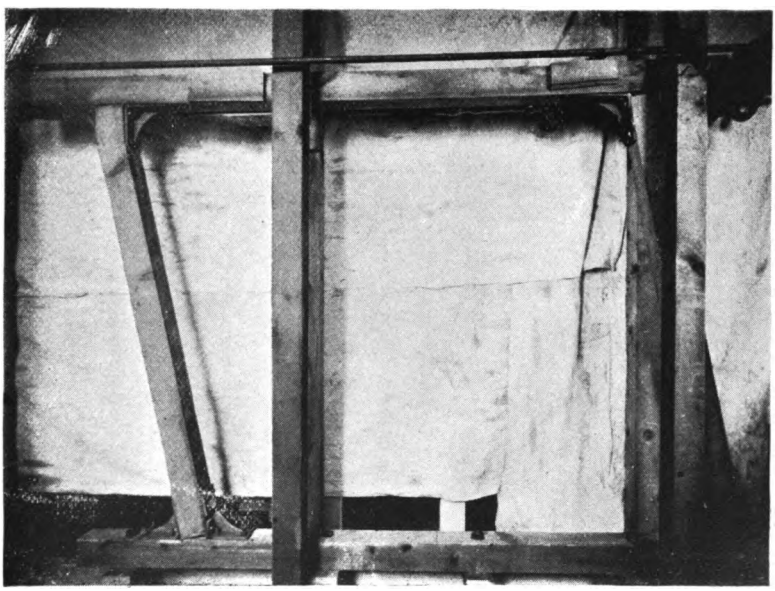

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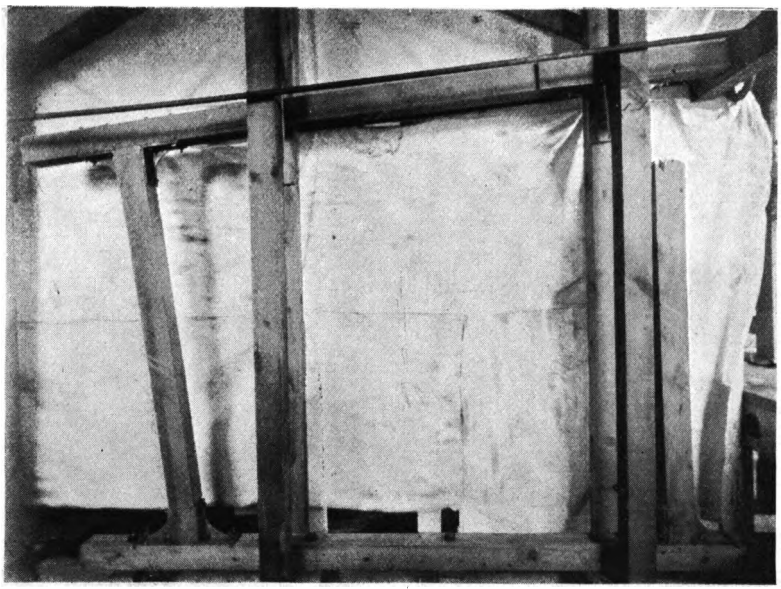

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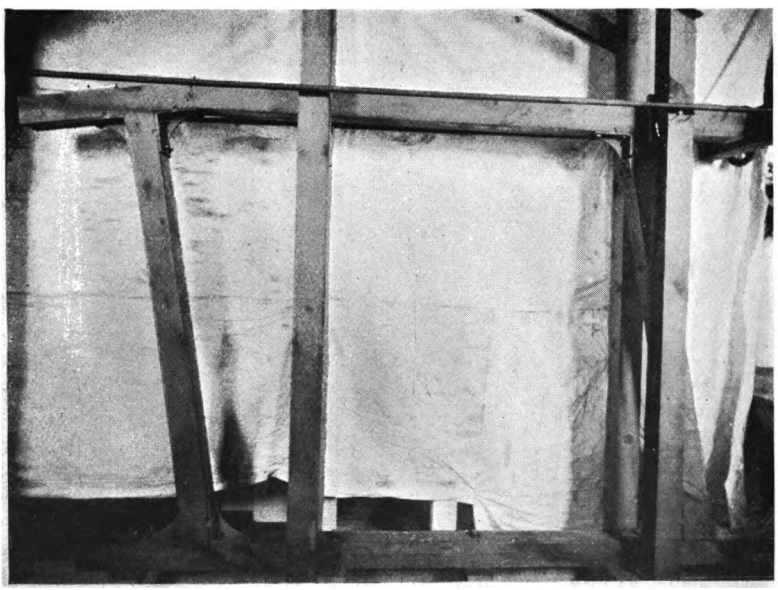

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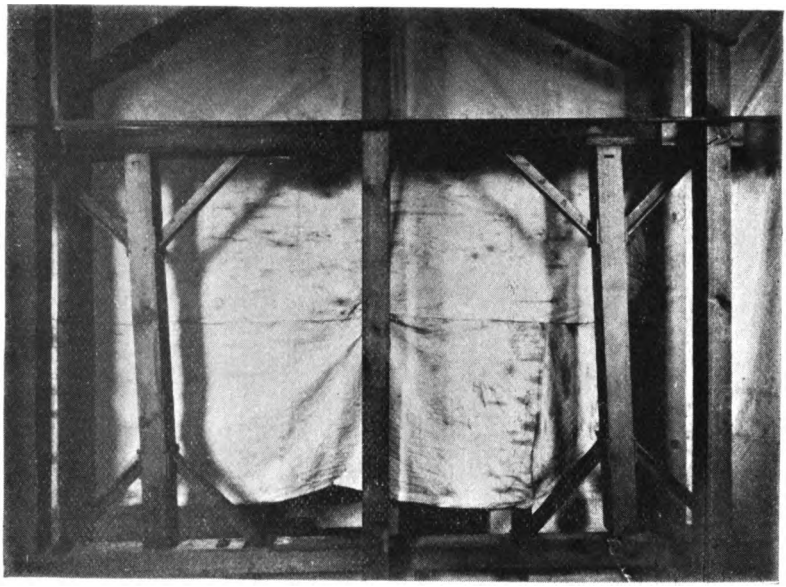

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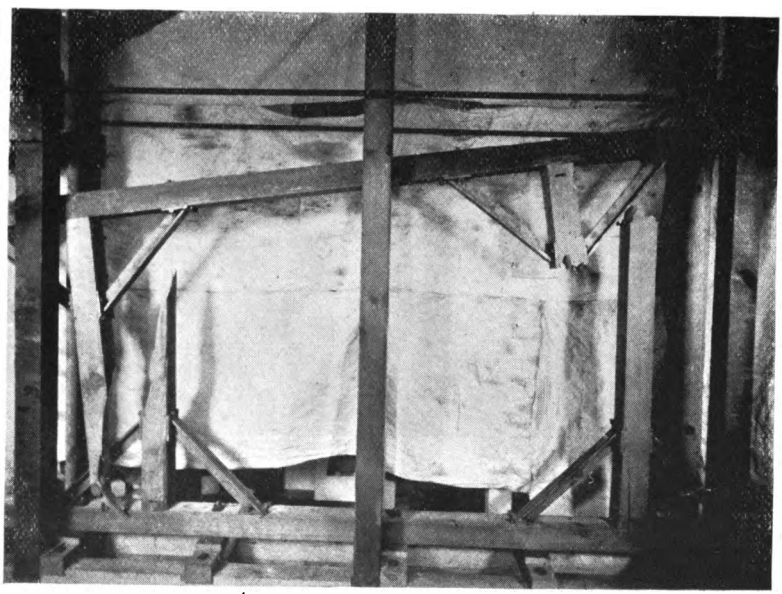

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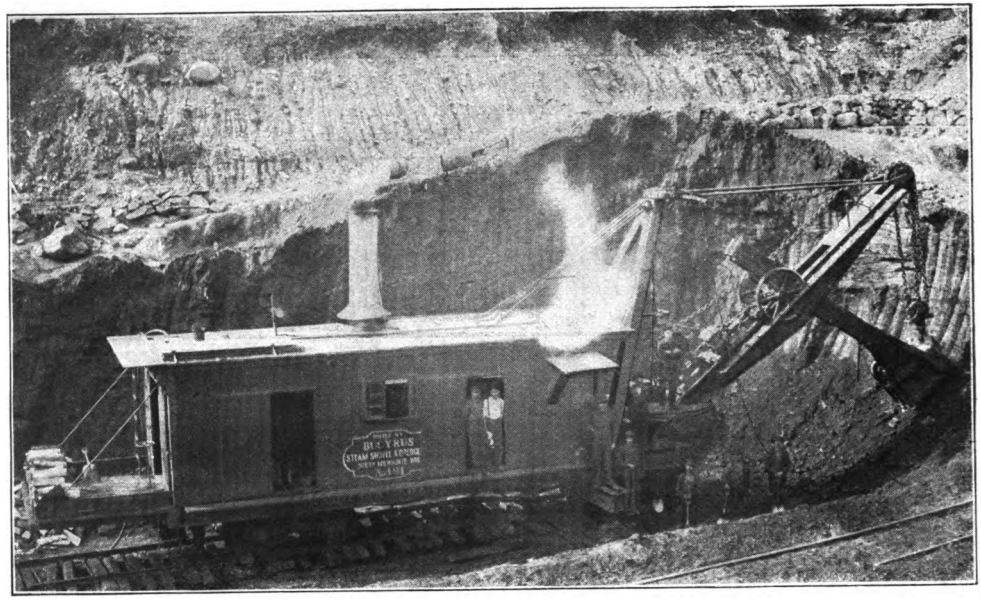

BUCYRUS STEAM SHOVEL.

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THE STEAM SHOVEL IN MINING.

BY A. W. ROBINSON, SOUTH MILWAUKEE, WIS.

It is proposed in this paper to take up briefly the design and construction of the steam shovel, and discuss the considerations which should govern the selection of a shovel to suit the work of the mining regions. It will be the writer's aim to look at the subject from an engineering standpoint, and also from the practical point of view of the mine superintendent, who desires only to arrive at what will be best for his purpose.

It may be stated at the outset that the requirements of steam shovel work in the iron ore regions are more severe than in ordinary work. Hence it has come about that in the early development of the ranges, a large number of shovels are sent in of similar character to those usually built for railroad or contractor's use, and which proved inadequate to the work. To insure the best results it is always necessary to study the conditions to be fulfilled and to see that the machine is designed to suit them.

Steam shovel work on the iron ranges is of three kinds, first, stripping; second, direct mining in open-pit; and third, loading from stockpiles. These occur under different conditions, although the general type of shovel required is the same in all.

The shovel to be used for stripping and mining should be able to load standard ore cars standing on a track at least six feet higher than the shovel track. By this means the work can be taken down in benches of not less than twelve feet, and a through track maintained for the cars. In a bank of less than twelve feet the shovel cannot work to good advantage, and it is better to have a bank of twenty to twenty-five feet. If the cut is less than twelve feet the cross-section is so small that more time is lost by frequent moves ahead and the dipper does

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not fill so well. To load flat cars on a track six feet higher than the shovel track, the dipper of the shovel should have a clear height of at least fourteen feet from the rail, on which the shovel stands, to the under side of the dipper door when open in the highest position. This height should not be the extreme limit of the shovel, but there should be a foot or so to spare. If the runner has to crowd the dipper up to the last inch to get his load on the car, he loses time. If the work is such that the car can always be on the same level as the shovel, then it will not be necessary to have such a high lift. Many shovels are built with a lift of ten feet, and as this is the usual height for railroad shovels, the lift desired should always be specified. It is better for the shovel not to carry the height of lift to an extreme. Twelve feet is a good height, and if the boom is tipped up beyond this it makes a bad lead for the pull of the hoisting chains upon the dipper. If the boom is increased in length in order to obtain the necessary height, its increased weight and leverage makes it slower to swing. It is, however, possible by preserving the proper position of the boom to obtain a height of fourteen feet without detracting from its efficiency or speed to any appreciable extent.

In direct mining from the pit, a powerful shovel is necessary, as the ore is generally hard enough to require blasting, and its great specific gravity as compared with earth is a greater tax on the hoisting and swinging power of the shovel. The softer ores can be worked successfully without blasting with a good and powerful shovel.

In loading from stockpiles there is not the same necessity for a high lift as in stripping, as the shovel need only be able to load cars on the level. The stockpiles being usually made in winter by daily accretions are a solid frozen mass by spring, and remain so far into the summer. When worked in this condition they require a stronger and more powerful shovel than either stripping or mining.

Endurance in hard work is the prime test of any shovel,—the ability to stand up to its work, week in and week out, without break-downs or delays. This subject of breakage is one of the most serious that confronts the mine superinten-

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dent. When he first begins to use a steam shovel (I am now describing the general run of shovels) it breaks down at a most unfortunate time and causes no end of annoyance and expense. He concludes that somebody has made a radical mistake in not getting that piece strong enough, or that the iron used by the makers was extraordinarily poor. He deems it the part of wisdom to have the piece replaced with another of double the strength, or perhaps made in cast steel instead of iron. It frequently happens that, after all this is done and everything going along all right, another break occurs, this time in a new and unexpected place. Now let us consider this question of breakages with a view to ascertaining whether it is not possible to prevent them. When a part breaks it may be assumed that it was too weak, but this is not necessarily so. It may be that, owing to faulty design, too much strain was concentrated upon it, or possibly the part should not have been there at all, but the result accomplished by better design in an entirely different manner. Now the superintendent is not a steam shovel designer or builder. He cannot undertake to reconstruct the faulty part on new and improved principles. All he can do is to repair it and make the part as strong as he can and go ahead. By and by the shovel is loaded down with several tons of additional iron, and the breaks become more infrequent, or break out in new and unexpected places due to the unequal strength and patching.

This is the common history of the generality of shovels that are put into hard and exacting work. This condition of things may be due either to errors in design, defective construction or error of judgment in putting in a shovel too weak for the work. It also frequently happens that the purchaser, in his efforts to be economical, gives his order for a shovel to the lowest bidder, forgetting that competition in price carries also with it competition in quality and strength. Or, distrusting his own judgment, not caring to go into mechanical detail, he buys the shovel on the strength of an absolute guarantee from the maker, and learns afterward that a guarantee does not in itself insure fulfillment.

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All these causes are remediable and it is possible by care and selection, skill in design and by liberality in using only the best materials and workmanship, to produce a shovel that will successfully withstand continuous hard work without break-downs. At the same time it will be conceded that a steam shovel in hard digging is called upon to withstand a more severe ordeal than any other class of steam machinery, and to do its work under harder conditions. People admire a powerful locomotive hauling a train at sixty miles an hour. It is a great development, but the steam shovel has to withstand a pounding, racking and twisting that are unknown in a locomotive. The locomotive is the evolution of years of concentrated skill, in which every part has become reduced to a form that is recognized as being the best by a process of "survival of the fittest." The steam shovel, on the other hand, has not received the same wide-spread attention from engineers, nor has its construction been reduced to a system which is recognized by leading builders as being the best. Hence it is that the shovels of different builders present widely different features of design. It is therefore important for every purchaser to be able to exercise a discriminating judgment with a view to purchasing that which will be best adapted to his particular work, and to avoid that which is faulty.

Generally speaking, a good shovel should be characterized by simplicity and strength. Every reduction that can be made in the number of parts required to do the work, reduces to that extent the liability to break down. But fewness of parts is of no value without strength and proper proportions, and the two must go together to produce the best results. The shovel throughout should bear the impress of intelligent design to preserve the proper proportion of strength and power. It is possible to put tons of iron into a shovel where it will do but little real good, and a shovel may be heavy and apparently massive, and yet deficient in some minor and secondary points, which do not appear until it is put to work. But to the steam shovel user no points are minor and secondary, and if they cause trouble they become of the first importance. Immunity from break-downs can only be secured by having *all* parts in

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due proportion and of a large excess of strength over the requirements.

If the strains in a steam shovel could be all calculated and closely determined it would be then a matter of common engineering skill to so proportion each part, with a suitable factor of safety, so that it would not break. Some of these strains can be calculated, such as the pull on the hoisting chain from a given pressure of steam, and this again produces certain reactions in the various members of the machine. But the strains due to the concussion of encountering immovable resistances, with the dipper striking at every conceivable angle, are such that they cannot be calculated, and any attempt to assume them from a static strain sheet and to proportion the parts on the basis of the usual allowance for such static strains will be misleading. The static strain sheet is a valuable guide, but experience is the only true teacher as to how much to allow for "contingencies" of the unknown elements referred to.

In Plate 1 is given a strain sheet of a 60-ton shovel, computed on a basis of 75 pounds mean effective pressure in the cylinders. Here the greatest strain on the A-frame and back guy would occur, with the dipper teeth caught under an immovable ledge, and with the dipper-handle free in the saddle-block. When the thrust motion is brought into play, or the dipper-handle held by brakes from slipping through the saddle-block, then transverse strains in the boom are set up, and the tension of the boom guy is reduced.

Let us consider now more in detail the elements which go to make up a shovel.

The car frame, or floor, is practically the foundation on which the shovel is built, and should form a solid frame to which the machinery is secured. The sills should be of steel beams, not less than fifteen inches deep, if the shovel is for heavy work. Many riveted connections are to be avoided, as also the combination of wood and steel for structural members. It is the writer's practice to attach the machinery and frame directly to the steel sills of the car, and after the shovel is practically completed in steel, a wooden floor and wooden

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house, or car-body are put on, but which form no part of the structure, and have nothing to do with its strength. The frame strains of a shovel are concentrated at the top and bottom crane supports, or gudgeons, upon which it revolves. These should have large bearing surfaces and be strongly supported. Many shovels are built with a post or mast about which the crane revolves. A post is entirely proper for sustaining vertical strains, but inasmuch as the horizontal components of the stresses at the points of attachment of the crane are vastly greater than the vertical, it is difficult to see its utility, and it is, in fact, an element of weakness. A rigid support for the top center is obtained in the most direct and simple manner by making it the apex of a tripod or pyramidal frame as illustrated in Plate I. The three members of this frame are pin-connected, and the maximum tension and compression upon them can be calculated with tolerable closeness.

The hoisting engines of the shovel call for close attention, but present no special problem. They should be strong, well built, of few parts and large bearing surfaces, and no fine adjustments. The latter provision is of special importance in view of the character of men usually employed to run steam shovels. They are not engineers or machinists, and it ought not to be necessary that they should be. A good engineer or a good machinist will seldom make a good steam shovel runner, and the engines should be so designed and constructed that all they require for their successful operation is plenty of steam and a little occasional oil. It is the writer's practice to make the cross-heads, for example, without any adjustment at all. They are of cast iron, in one piece, and run in solid bored guides. The bearing surfaces are, however, so unusually large as to do away with the necessity for adjustment. The length of the cross-head is in all cases equal to the stroke of the engine, and broad in proportion. Cross-heads made in this way will last indefinitely, and frequently at the end of a year they will not have worn off the tool marks. Properly constructed engines will outlast every other part of the shovel and give no trouble. Care should be taken that they are not too large, and a shovel to be safe and reliable should be under-

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powered, rather than over-powered. In other words, the engines should be the weakest part of the machine, and all other parts should be proportioned so as to safely withstand the strain due to encountering immovable resistances with the throttle wide open and 100 pounds of steam.

The boom, or crane, of the shovel is the part subjected to the greatest variety of stresses, and too much care cannot be bestowed upon it. It should be as strong as possible without being heavy, for if it is unduly heavy, not only is it a load upon the front end of the machine, but its inertia will prevent its rapid swinging. Concerning the relative merits of boom versus crane, the writer prefers the boom for the reason that it is simpler, lighter and less rigid than the crane. The positions of the working parts and action are, however, practically the same in both.

Hoisting and swinging friction clutches, or "frictions," as they are more briefly termed, should be of some standard type and of large bearing surfaces, The band friction, lined with wood blocks, is to be preferred to the cone or other types.

A good thrust motion should form part of the equipment of every first-class shovel. This is an appliance for feeding the dipper in and out, and is of a special value in hard digging. In soft material, however, it is frequently dispensed with entirely. The thrust motion may be of two kinds: First, frictional, in which the power for thrusting out the dipper is derived from the main engines, or from the hoisting chain by means of a friction clutch, and, second, independent engines upon the boom. The former arrangement answers every purpose for ordinary work, provided the friction clutch and all its parts are substantially constructed and have plenty of bearing surface. Independent engines add somewhat to the complication of the machine, and involve the necessity of carrying steam out to the boom through a swivel joint, or rubber hose, which is far worse. The independent engines, however, give much greater command over the action of the dipper, and are recommended as being the best equipment. Too much care, however, cannot be bestowed upon the thrusting engines, and it would be better to have none at all than to have them in-

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ferior or unreliable. They should be composed of few parts and have the bed-plate for the two cylinders cast in one piece, with heavy flanges and ribs to fit the boom, and to practically constitute a brace for it and made as strong as possible. The independent engines for thrust motion have two additional advantages over the frictional thrust motion. They give independent control of the dipper when working among boulders, and also enable the dipper to be thrust in or out to get the proper position over the car for dumping, and, furthermore, they increase the power of the machine by leaving the whole power of the main engines available for digging instead of subtracting a portion of it as is the case with frictional thrust.

The sheaves of a first-class steam shovel should, as a rule, be much larger in diameter than are generally seen. Few persons are aware how much power is lost by running a chain over a small sheave, and not only that, it causes enormous wear and tear. It is a frequent occurrence to find hoisting chains and sheaves wearing out within two or three months, and sometimes less, when by the use of a first-class chain to begin with, and properly designed sheaves, they ought to last a year or more. It is the writer's practice to make the diameter of the sheaves about twenty-five times the diameter of the iron of which the chain is made, but the majority of sheaves are very much less than this. It costs money to provide large sheaves and large bearings for them, but it is the only way to insure durability. On high-class machines, where cost is not an object, all the sheaves should be made of steel and of as light a section as is consistent with their strength. If they run lose on their shafts they should be bushed with phosphor-bronze, and have very long bearings. It is bad practice to have sheaves run loose upon their shafts, if their bearing upon the shaft is short, but frequently it becomes advisable to make the stationary shaft constitute a brace for the parts, as, for instance, at the point of the boom, and loose sheaves should only be used provided they have a bearing upon the shaft of a length at least equal to half their diameter, and with ample provision for lubrication.

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The trucks of a steam shovel should in all cases be specially designed for the work, as a truck which will answer perfectly under a freight car will not do the work under a steam shovel. In the steam shovel it is necessary to block the wheels on the track, and the surging of the machine against this resistance causes transverse strains in the bolster of the truck, which should be specially provided for. Pressed steel trucks have been used to some extent with the object of reducing the number of parts, but they are open to the objection that they cannot readily be repaired when injured. The trucks are liable to be struck with boulders, etc., and should be of such a character that they can be readily repaired. The writer advocates an all-steel diamond truck, having extra heavy arch bars and a bolster formed of two steel I-beams, with riveted plates top and bottom, so as to form a solid box girder. All the castings of the truck should be extra heavy and of steel, in a high-class shovel, and the journals and bearings should conform to the standard.

The jack arms should be strongly constructed and of a distance apart from the screws to give the requisite stability to the machine when working. It is convenient to have them fold up as in a railroad shovel, but this should not be done at any sacrifice of strength. The jack arms are frequently attached to the car in such a way as to act as a lever for breaking it or twisting it out of shape. Too much care cannot be bestowed on the attachment of the jack arms. It is the writer's practice to have them pin-connected, and to attach the upper member directly to the base of the A-frame and the lower member to a continuous truss across the car. In this way the A-frame forms part of the truss, and it is in fact a triangle, having the point of attachment of the boom at its apex and the jack screws forming its base, giving obviously the most direct possible support for the strains, and without straining the car in any way.

The boiler of the steam shovel demands close attention, as it is frequently the point upon which the cost of construction of a machine is cheapened in order to meet competition. It is possible to make a steam shovel operate successfully for a

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time by using a small vertical boiler, and forcing it to its utmost, but for steady, reliable work, a horizontal or locomotive boiler, should be used, of ample size, and of the best materials and workmanship. The exhausts from the engines may be always from the stack, but it should not be necessary to use a small exhaust nozzle or a sharp blast. The boiler, therefore, should be large enough to supply the steam with ease, as this means not only durability of the boiler, but economy of fuel. In high-class shovels the boiler should be covered, and should be fed by an independent steam pump, as well as an injector, although frequent practice is to have a naked boiler and injector only. The coal space on a steam shovel is a point that is frequently neglected and should not be overlooked. As to the capacity of the water tank, there is no special object in having it unduly large. It is necessary to have a pipe line or hose to the machine in any case, and which is, therefore, practically a constant supply.

Having gone over all the foregoing points, and being assured that they are satisfactorily met, it then becomes of importance to see that the shovel is in careful hands and properly run. Much depends upon the judgment and skill of the runner. His work calls for alertness and the constant exercise of judgment, so as to make the most of every motion, and a skillful man will get the most out of a shovel without subjecting it to unnecessary wear and tear. The work should be made as easy for him as possible, and therefore all the movements of the operating handles should be easy and responsive and without lost motion.

In conclusion it may be said that a steam shovel, designed and built in a liberal manner to fulfill the conditions laid down, and properly run by a man who takes an interest in his machine and its work, will be a credit and satisfaction alike to its owners and makers. Such a machine, although it may cost a little more money at the outset, is the best investment. The iron ranges can no more afford to be without first-class, powerful steam shovels of modern design than the railroads can afford to be without modern and powerful locomotives. The great advances which have been made in recent years in the locomotive, should find their counterpart in the steam shovel.

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THE OCCURRENCE OF COPPER MINERALS IN HEMATITE ORE, MONTANA MINE, SOUDAN, MINNESOTA.

The two parts of this paper have been prepared independently. The description of the occurrence was written for the Minnesota Iron Company's records by Mr. J. H. Eby, engineer, and is here published by permission of President D. H. Bacon.

The mineralogical examination has been carried on in the Mineralogical Laboratory of the University of Minnesota by Mr. Charles P. Berkey, and is based upon a complete series of specimens illustrating this remarkable association. Mr. Berkey has kindly consented to the publication of his results.

In reply to a letter of inquiry Prof. C. W. Hall writes:

"I think Engineer Eby has given a very clear and complete statement of the occurrence—no further points occur to me.

The question of the genesis and chemical composition of the material found in the several ores of copper are entirely distinct questions, and should afford the subject of further study and discussion."

Prof. Thos. Egleston writes of the occurrence as follows:

"I have heard of the occurrence of native copper in this association, but I have never seen it, and I have never seen any explanation of it. The precipitation of native copper, of copper oxide and oxide of iron, is not an unfrequent occurrence in metallurgical establishments, but it is never seen in this particular condition, as in these establishments it is never subjected to any very high degree of pressure. I have several such specimens from Europe in my own collection, and I believe it is not uncommon in European mines, but I have no specific information in relation to such specimens in this country."—*Secretary.*

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PART I.

DESCRIPTION OF THE OCCURRENCE, BY J. H. EBY.

About January, 1896, the presence of copper was indicated by the appearance of fine coatings of Malachite (Cu_2, CO_4, H_20, hydrous copper carbonate) upon the hard hematite ore extracted from the fourth level of the Montana Mine at a point 850 feet from the shaft. These indications of copper kept growing stronger, and a few pieces of native copper were said to have been found.

The Montana vein is a body of hard hematite, of bessemer quality, and high in iron; and is really a group of veins, the partitions between which become thinner as they extend westward, where the group apparently forms one large vein over eighty feet in width. The walls and partitions are composed of the very softest kind of soap rock and do not contain, nor do they show that they ever contained, metalliferous minerals.

The ore-body dips to the north at about 78 to 80 degrees, and pitches to the west at an angle of between 25 to 30 degrees. The veins of ore as they extend to the east pinch down to thin seams, and finally end entirely in the body of soap rock; while to the west on the second level (96 feet above the fourth, the third being dropped) it terminates against a body of jasper which forms a capping.

The specimens of copper appeared in a flat seam in the back of the breast stope of the most southern vein, fifteen feet above the floor of the fourth level, and extending west, keeping at the same height, but dipping 11 to 12 degrees towards the south. The extreme southern side of the seam was from three to ten feet north of the foot-wall, and extended 20 to 25 feet across the vein. The point where the signs of copper first appeared is about sixty feet below the jasper cap, and 265 feet below the surface of the ground. The thickness of the seam was from one-fourth to one-half inch. While no traces of malachite were to be observed above it, the ore was coated with it from three to five feet below, and often good specimens were to be found at that distance.

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Until the breast had advanced eighty feet after the presence of copper was first noted the seam was filled with malachite, and not until then was there any native copper of importance found. The copper occurred in sheets one-fourth to one-half inches in thickness, and it was not entirely confined to the seam, but frequently extended through small crevices in the adjoining ore. At the point of contact with the ore the copper was altered, first to cuprite (Cu_2O, red oxide of copper), then to malachite, and in some cases to azurite ($Cu_2C_2O_7$, blue copper carbonate).

That the copper was altered to its oxide and carbonate was shown by the occurrence of an octahedron, the center of which was copper, the next layer oxide, and the outside carbonate.

Specimens of sheet copper were found as large as six by ten inches, and some were remarkably well crystalized and free from alteration products.

The seam has continued thirty feet farther than where the first important specimen occurred, and native copper is still to be found in varying quantities. One or two specimens of chalcopyrite (Cu Fe S_2, copper and iron sulphide), the size of a pea, were found, but as no importance was attached to them at the time, their position with relation to the seam was not noted.

No record can be found of any previous occurrence of copper ore in any of the workings, either on this or any other vein in the vicinity,

The accompanying sketch will show the position of the seam with relation to the foot-wall and ore-breast.

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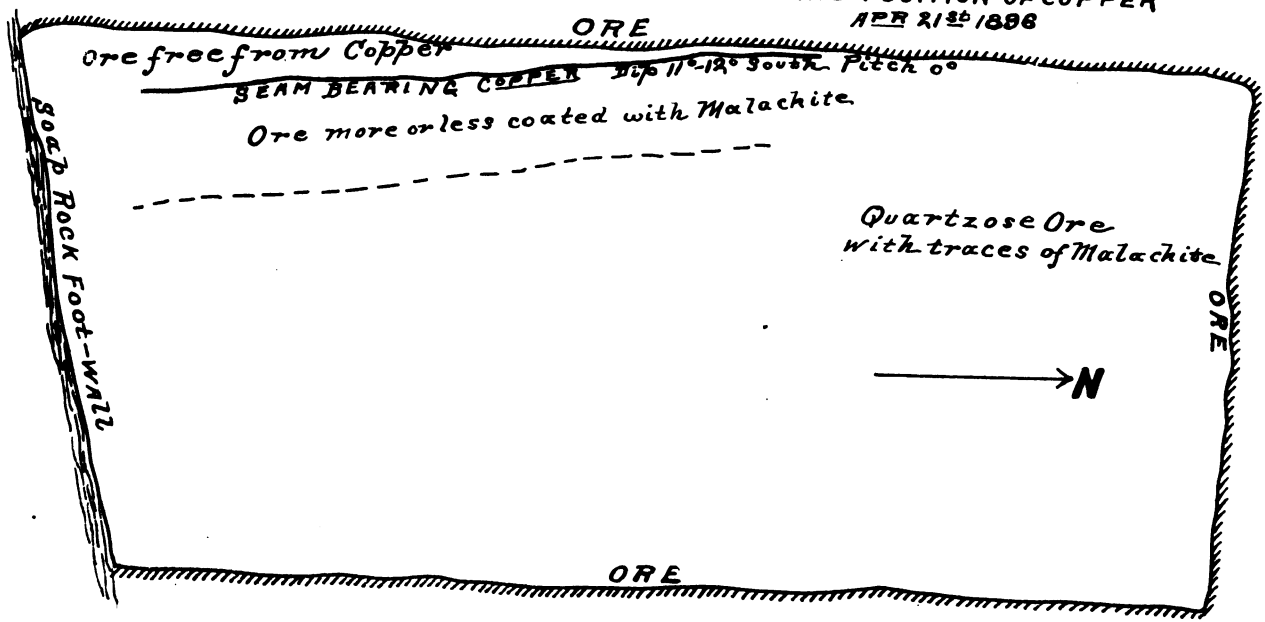
MONTANA MINE

VERTICAL PROJECTION SOUTH BREAST 4th LEVEL

LOOKING WEST SHOWING POSITION OF COPPER

APR 21st 1898

Scale
0 1 2 3 4 5 6 7 ft.



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PART II.

STUDY OF THE MINERALS, BY CHARLES P. BERKEY.

In the series of specimens presented to the University of Minnesota, all phases of the associated minerals appear, with the one exception of the chalcopyrite mentioned by Mr. Ebv. No specimen at hand shows this mineral. In September of the present year (1896) Mr. Eby added two specimens illustrating unusual phases of the "soap rock" enclosing the ore-body.

The specimens are grouped and entered in the catalogue of the Department of Geology and Mineralogy under the serial numbers 1591-1598 of the mineral collection, and 3901-3902 of the rock collection.

No. 1591—Chiefly hematite with copper, cuprite and malachite; one specimen.

No. 1592—Largely metallic copper, coated with cuprite and malachite; three specimens.

No. 1593—Chiefly hematite with cuprite, malachite, copper, silica and ochre; three specimens.

No. 1594—Chiefly metallic copper, originally crystallized, coated with cuprite and malachite; three specimens.

No. 1595—Mostly hematite, with cuprite and malachite crystals and azurite; five specimens.

No. 1596—Largely cuprite with malachite, hematite and copper; ten specimens.

No. 1597—Largely hematite with copper, cuprite and malachite and ochre; one specimen.

No. 1598—Chiefly hematite with cuprite, malachite, azurite, copper and silica; five specimens.

No. 3901—"Carbonaceous shale," twelfth level cross-cut, Minnesota Mine; one specimen.

No. 3902—The "soap rock" of the mine from a horse rock, between north and south veins, fourth level, Montana shaft. The chief point of interest in the specimen is a small quantity of metallic copper which appears in the filling of a narrow vein; one specimen.

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Hematite—The original mineral of the specimens, so far as the present discussion is concerned, is hematite. The fact that the various copper compounds are not scattered promiscuously through the ore, but are wholly confined to the lines of fracture in the brecciated mass and are without exception either cavity fillings or surface coatings on the hematite seems to place this conclusion beyond question. There is, however, a later development of red ochre and minute hematite crystals. This will be referred to later on.

Copper—(A). In the ore-body.—The metallic copper seems to be the earliest accessory mineral. It has been largely altered since the original precipitation, to the secondary products next to be mentioned; but such specimens as still bear the metallic copper present many points to support this view. Chemical tests disclose no impurity in sufficient quantity to warrant analysis, either of the metal or indeed of any of the secondary products. The native copper occurs in sheets from the seam in the ore, (No. 1592), and in partially obliterated crystals coated with cuprite and malachite, (No. 1594), and also in isolated threads and grains, (Nos. 1591, 1593, 1596, 1597, 1598 and 3902). The evidence that copper is the primary mineral is stated below:

1. The original crystals and crystalline grains of copper remain, even with all surfaces coated by alteration products.

2. Cuprite, malachite and azurite all occur below the seam carrying the chief amount of metallic copper.

3. There is a constant occurrence of copper within an area of cuprite, with no noticeable development of porous zones. If the metallic copper were a result of the reduction of cuprite, there would be a shrinkage in volume of 39.96 per cent. This process is always attended with the development of porous pseudomorphs. But, on the other hand, when cuprite alters to malachite, an increase in volume of 235.17 per cent results,* which is in entire accord with the bulging faces of the original crystals of copper now coated with cuprite and malachite.

* Elements of Chemical and Physical Geology, Gustav Bischof, translation by Benjamin H. Paul V,ol. III., P. 533.

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4. The copper specimens freest from secondary products come from parts of the seam which were filled with sheets of copper, and show only thin coats of other minerals.

The foregoing points seem sufficient to establish metallic copper as the primary mineral of the group. None of the specimens furnish any dissenting evidence. The record of the discovery suggests no other view, unless the report of chalcopyrite, noted by Mr. Eby, can be so construed. But, on account of the apparent lack of reliable data and the total absence of any trace of this mineral in the specimens, it cannot receive serious consideration.

(B). In the adjacent rock.—Small amounts of native copper occur quite free from alteration products in specimen 3902. It is confined, however, to the narow vein, and tests applied to other parts of the specimen do not show any trace of copper.

Cuprite—The red copper oxide, cuprite, Cu_2O, is one of the most abundant minerals present in the specimens. It is very pure; is clear red in color to very dark red; is thoroughly crystalline, and at some points is fairly well crystallized. The forms recognized are the cube, octahedron and the dodecahedron. All are small and rather imperfectly developed, (No. 1592). It is always found on the specimens at hand and is a constant enclosing matrix for the metallic copper. There is no specimen of the metal without at least a thin coating of this oxide. It always forms an intermediate film between the native copper and the malachite. In many places it is quite compact and completely fills the fissures in the brecciated ore.

Malachite—The green carbonate, malachite, $Cu_2(OH)_2CO_3$, is as plentiful as the oxide. Its position is always next outside the coating of cuprite, when the two are in contact. But it extends further as a surface coating on the fragments of the ore than has been reported for any of the other minerals. There is no impurity in the better specimens. Many show fine groups of acicular prisms of very small size lining a few of the cavities. Others have the usual velvety or earthy characters, (1595 and 1598).

Azurite—The blue carbonate, $Cu_3(OH)_2(CO_3)_2$, occurs in small amount associated directly with the malachite or hem-

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atite. A few specimens show crystallized azurite, (1598). It is not at any point in direct contact with cuprite or metallic copper. Its most usual position is directly in contact with the hematite in small cavities.

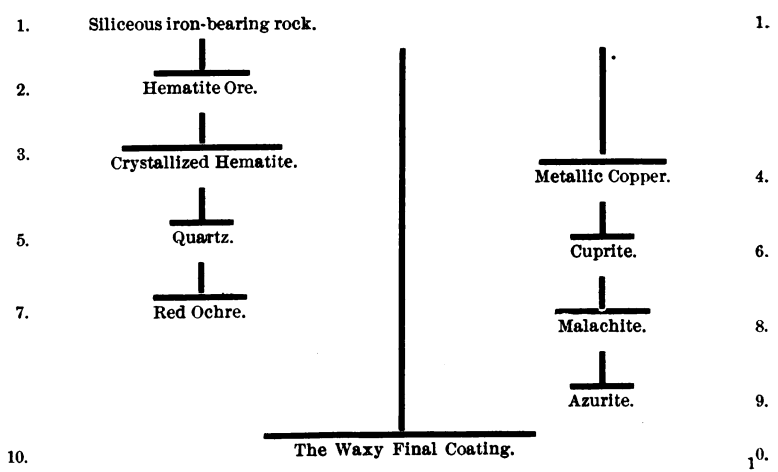
Crystallized Hematite—Many areas of the ore are covered with a sparkling coat of hematite crystals, which are at least older than the malachite, (Nos. 1593, 1598.)

Quartz.—A white and sometimes porous substance, reacting chiefly for silica, occurs sparingly as a coating and fissure filling in a few specimens. It is most closely associated with earthly hematite, and portions are colored yellow, etc., by oxide of iron. (Nos. 1593, 1598).

Earthy Hematite.—In a few limited areas there is a very bright red ochre. It was at first thought to be "tile ore," but examination proves it to be iron oxide. (Nos. 1593, 1597).

Later than any of the minerals mentioned above is a reddish yellow, waxy film which covers some surfaces of the malachite. It is so exceedingly small in amount and so difficult to obtain in a pure state, that all attempts to satisfactorily determine it were unsuccessful. It contains silica, alumina, iron, calcium and traces of magnesia.

Paragenesis.—The relationships of the different minerals may be seen by the following diagram:



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Origin.—It is difficult to give a satisfactory explanation of the origin of this remarkable deposit. In the first place, however, it is narrowed down to a question of the origin of the metallic copper. The origin of the hematite is beyond our discussion. The oxide and two carbonates of copper are clearly secondary or derived products of the metallic copper by the action of water carrying oxygen and carbon dioxide. The cuprite developed first by simple oxidation. Malachite formed next by the addition of water and carbonic acid, and azurite was formed last by the further action of the same process.*

Thus far the explanation seems to be borne out by the facts of occurrence. But the original source of metallic copper is not reached. It is reasonable to suppose, however, that the immediate source was a copper solution, either a sulphate, corbonate or silicate, from which the metal was deposited as a precipitate through the agency of ferrous oxide.**

This supposition seems to be so suitable in the case before us that the theories*** sometimes brought forward in explanation of the occurrence of copper will not be noted.

As to the ultimate source of the copper data for satisfactory conclusions are not at hand. The three or four points which have any bearing on the problem are:

First—The limited amount of copper present;

Second—The local character of the occurrence;

Third—The comparatively recent development of the cupriferous minerals; and,

Fourth—The occurrence of metallic copper in the inclosing rock.

In accordance with these facts the following explanations are chosen as the most reasonable:

First—Small amounts of copper are scattered through the strata adjacent to the ore bodies, of which specimen No. 3902 is a fair example. By some change in the underground cur-

*Elements of Chemical and Physical Geology, Gustav Bischof, translated by Benj. H. Paul, vol. III., p. 509, 1854.

** Geology of Michigan, Vol. I., pt. II., p. 43-46.

** The Copper-Bearing Rocks of Lake Superior, R. D. Irving, U. S. G. S. Monograph V. p. 425.

*** Geology of Wisconsin, vol. I., 1873-1879, p. 110-114.

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rents, this deposit was developed as a segregation. In such case, we should expect similar deposits at other points and we should detect a wider distribution in a district where so many mines are similarly situated. Specimen No. 3902 is the chief support for this explanation. But it comes from the immediate vicinity of the copper minerals, and instead of indicating a source of supply, the country rock copper many indicate the limit of penetration of the copper bearing waters.

Second—The original Keweenawan rocks were at one time more extensive than now. They doubtless have covered this very district in some period of preglacial time. They are noted for their copper producing minerals. If we assume that solutions derived from the decay of these rocks had ready access to the locality under discussion, it would form the basis of a suitable explanation.

Third—A surface erratic or local accumulation in the glacial drift would furnish conditions apparently consistent with the facts at hand. The chief objections are: The depth of the copper and cupriferous minerals below the surface, and the very recent origin of the glacial drift itself.

Of these three possible sources no one is perfectly satisfactory to the writer. Work among the iron deposits is not far advanced, and in all probability additional data will soon be forthcoming that will be of more service in this question.

So far as the writer is aware there has been no previous report of any considerable segregation of copper minerals in workable deposits of iron ores. The only analysis at hand, furnishing anything definite from an American locality, is that of the Cornwall iron ore deposit in Labanon county, Pa. In this ore there is reported* an average of about one per cent of copper oxide, melaconite, and about six-tenths of one per cent of copper pyrites.

Oxide of copper with some carbonate occurs with decomposed specular ore** near St. Clair, Franklin county, Missouri; and metallic sulphides occur sparingly in the Ozark region.***

* Mineral Resources of the United States, 1883-1884, p. 270.

** Geology of Missouri, vol. II., Report on Iron Ores, 1892, p. 95.

*** Geology of Missouri, vol. II., Report on Iron Ores, 1895, p. 153.

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Cuban ores also carry an appreciable amount of copper, estimated at about 0.05 per cent,* but in this case I am not sure of the mineral or chemical combination in which it occurs. Judging, however, from the amount of sulphur reported as an impurity, one would expect to find it as a pyrite. This is apparently the most common copper mineral found in iron ores.

It is not an unusual thing to encounter copper as an impurity in iron and steel, and as a furnace product in the metallurgy of iron and steel. But it is commonly in such minute quantities that no detrimental effect is produced, although two per cent of metallic copper, and usually very much less, will seriously interfere with the working of iron, ** making it red short. A brief discussion of this subject does not necessarily include a treatment of the effect of copper as an impurity in iron, but has been referred to in order to furnish a basis for whatever is new in the discovery of copper in the Montana mine at Soudan. Even after taking account of the occurrences noted above, the following points still distinguish this discovery and claim for it an addition to our knowledge of the association of these minerals:

1. A seam of metallic copper occurs in workable hematite ore,

2. In which alteration has produced the red oxide, cuprite, and the carbonates, malachite and azurite.

3. This within a limited zone in a mine not showing any other like development, and,

4. In one of the greatest iron districts of the world where no other mine has yet shown a similar occurrence.

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*Note on Copper in Iron and Steel, by R. W. Raymond, Trans. Am. Inst. Mining Engineers, Colorado Meeting, 1896.

**Notes on Copper in Iron and Steel, by R. W. Raymond, Trans. Am. Inst. of Mining Engineers, Colorado Meeting, 1896.

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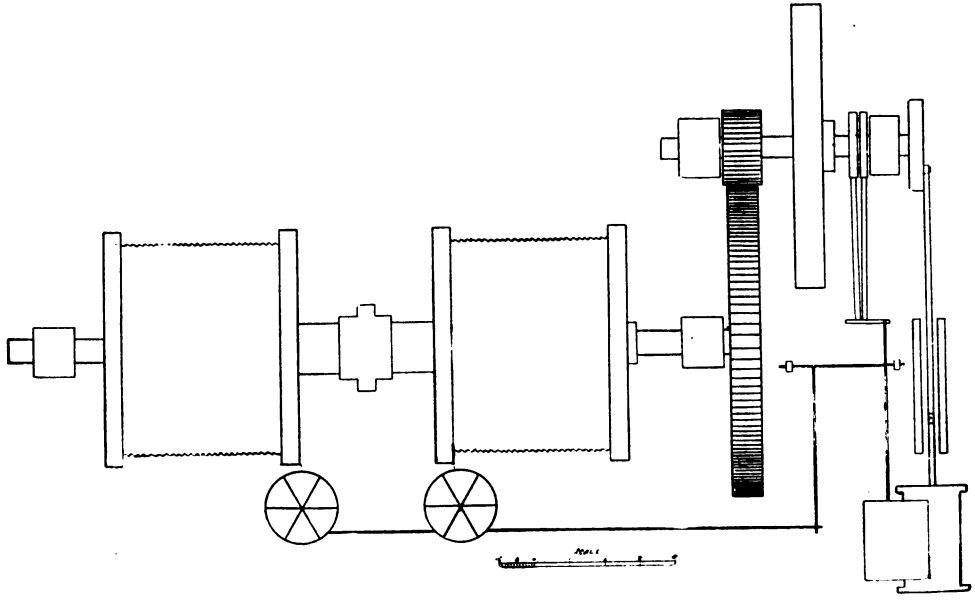

SINGLE-ENGINE HOISTING PLANT.

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A SINGLE-ENGINE HOISTING PLANT.

BY T. F. COLE, NEGAUNEE, MICHIGAN.

During November, 1889, the writer was called to superintend the work of mining ore at the Queen, Prince of Wales, Buffalo and South Buffalo mines. At the Prince of Wales the former operator had purchased and installed a hoisting plant consisting of one 18 x 24-inch valve engine geared to drive two six-foot diameter by five-foot face hoisting drums. On the crank shaft was placed a fly wheel eight feet in diameter to steady the engine. The machinery was built by the Iron Bay Manufacturing Company of Marquette, and designed to hoist single skips or cages in one or more compartments of a shaft or shafts. The shaft at that time being sunk was vertical and soon reached a depth of 265 feet from the surface and the first level was opened. The ore on this level was small in quantity, and the shaft was sunk to a depth of 310 feet and the second level opened. The ore on this level was of small proportions, consequently up to this time only one compartment of the shaft was used for hoisting ore through. The ore in this mine was pitching at an angle of 38 degrees to the west, and away from the shaft. To determine if we would find an increase in the size of the ore lens below the 310-foot level, we sunk a small shaft in the ore from this level to a point 65 feet below, and on opening the ore body with drifts and cross-cuts from the bottom of the small shaft we found the ore area had largely increased, and the whole outlook was so favorable that we decided to sink the main shaft 140 feet more and drive 465 feet through rock on this new level to reach the ore. This work was done, the drift being of sufficient width to permit of our installing a rope haulage plant, using double tracks to tram our ore an average distance of 680 feet from stopes to shaft.

The ore area on this 450-foot level was of sufficient size to

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cause us to cast about and find some means of hoisting a large quantity and at a minimum cost.

	Pounds.
The weight of skip was	2,200
450 feet 1⅛-inch wire rope (approximately).	1,000
Load of ore	4,600
Total	7,800

Each drum was operated by power transmitted to it from the drum shaft by means of an outside band friction, and we found that the strains on the engine and frictions were becoming too severe for the good of the machinery or for safety. The only way to secure economy was to run our skips in balance, and it was decided that, by adding another eccentric with link and tumbling block, we could make that single engine accomplish what we desired. The work on the engine was quickly done by the Lake Shore Iron Works of Marquette, and gives good satisfaction.

To reduce strains on driving frictions, we decided we could pass a rope over the sheave on the top of the shaft house with each end fastened to the bail of skip in either compartment of the shaft, and taut enough to take the weight of the skips off the friction. Then the question of getting our men into and out of the mine led us to put cages in both compartments of the shaft and the total weight of the cage, car, ore and rope was then reduced from former load so that the frictions would hold with safety.

This machinery is now hoisting daily 800 tons of ore from 450 feet in depth, operating the cages in balance. We stop the engine each trip of the cage and find no difficulty from engine centering. Any one having a similar plant can utilize it to hoist in balance, and if drum capacity is sufficient, 1,000 tons per day can be raised from the depth of 700 feet or under, provided the cars are delivered at the bottom of the shaft with fair regularity. This is the first attempt the writer knows of where a single engine has been utilized to hoist cages working in balance.

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The economy of the plan is fairly illustrated by the fact that one 5-foot diameter by 16-foot long tubular boiler is easily furnishing sufficient steam to operate the engine, heating a one-story building 12 x 36 feet, and a one-story dry building or change house 24 x 160 feet in size, driving a No. 7 Cameron pump located at the bottom of the shaft above mentioned, that elevates 45 gallons of water per minute 140 feet to the main pumping plant, and furnishing power to operate the rope haulage plant that is tramming daily 800 tons of ore an average distance of 680 feet.

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THE PIONEER MINE PUMPING ENGINES.*

BY H. B. STURTEVANT, ELY, MINN.

I beg to submit the results on two efficiency tests, on our Prescott mine pumping engines. They are of the compound duplex plunger type, with pot valves, three valves in each pot. One of these pumps throws water from bottom of "A" shaft to surface, a distance of 780 feet vertical. This is the one tested. The other is stationed 150 feet higher, and is used when necessary, as a relay pump; a smaller duplex throwing to it.

Dimension of pumps are: high pressure cylinders, 16 inches in diameter; low pressure cylinders, 30 inches in diameter; plungers, 9 inches in diameter, and stroke 24 inches.

Condensers are single acting, independent type, 10 x 14 x 16 inches. The main steam pipe is 6 inches in diameter and 1,100 feet long from boilers to pump, and is covered with Manville covering. It has two expansion joints in the shaft. The column pipe is 8 inches inside diameter.

The rated capacity of the pump is 600 gallons per minute under a pressure due to 800 feet head with dry steam at the pump at a pressure of 90 pounds per square inch.

The boilers used were the Stirling water tube boilers, of which there are four; each of 150 H. P. capacity. On the tests two of these boilers were used. The gauge pressure carried is from 110 to 120 pounds.

On each of the caps of the discharge valve chambers of the pumps there is a small air chamber made of four-inch pipe. The air chambers are twelve inches long and are connected with the valve chambers by one inch pipes and globe valves. The effect of these air chambers is to make the valves seat

* The original of the above was submitted to the Ishpeming meeting of the Institute in August, '96. But has been rewritten to include a test made since then. H. B. S.

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easier, as is manifested by the absence of any clicking sound; and further, the effect is to start the valves with less steam pressure, or, in other words to increase the valve area, on the theory that the air in the water passing through rises to the top of the air chambers and affords air cushions. To our master mechanic, Mr. R. J. Williams, belongs the credit of this contrivance, which has not been used elsewhere to our knowledge, and which we recommend for the consideration of mining men.

We attempted to determine the actual slip of the pump; but owing to the irregular shape of the cistern, our test was not satisfactory, and we therefore assumed the slip to be five per cent, which is reasonable, as the pumps have been in use but seven months, and are in good condition.

The first test was made on July 9th, 1896. Some of the details as to evaporation were not satisfactory, and are not given.

Revolutions of pump per minute, 18½.

Displacement, 489 gallons per minute, or 80 per cent of rated capacity.

Lift, 780 feet vertical.

Steam pressure throttled to 75 pounds on gauge at branch pipe.

Vacuum, 27 inches.

Duration of test, 8 hours, 35 minutes.

Coal consumed per minute, 11.8 pounds.

Ashes, 10 per cent.

Foot pounds effective work per 100 pounds coal, 28,560,000.

Foot pounds effective work per 100 pounds combustible, 31,730,000.

THE SECOND TEST WAS MADE ON OCTOBER 4TH AND 5TH, 1896.

Duration of test, 19 hours.

Temperature of feed water, 68 degrees.

Boilers fed by Hancock inspirators.

Coal consumed, 12,600 pounds; or, 11 pounds per minute.

Ashes and clinkers, 1,565 pounds; or, 12.4 per cent.

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Combustible used, 11,035 pounds; or, 9.72 pounds per minute.

Water evaporated in 785 minutes, 8250 gallons; or, 87.5 pounds per minute.

Evaporation per pound of coal, 8.0 pounds water from 68 degrees.

Evaporation per pound combustible, 9.0 pounds water from 68 degrees.

Evaporation per pound combustible, 10.76 pounds water from and at 212 degrees F.

At the pump:

Revolutions per minute, average 16½.

Displacement, 436 gallons per minute, or 72 per cent of rated capacity. Slip assumed at 5 per cent.

Stream pressure throttled to average of 67 pounds per gauge.

Vacuum, 27 inches.

Revolutions of condenser, 25.

Foot pounds effective work, per minute, 2,691,000.

Foot pounds effective work per 100 pounds coal, 24,460,000.

Foot pounds effective work per 100 pounds of combustible, 27,740,000.

This may be taken as the actual duty on the entire plant of boilers and pump together.

In practical tests on mine pumping engines, we must figure from the coal and water used at the boilers; assuming the steam pipe line to be of proper size and well covered. However, were we to figure from the dry steam at the steam chests, we would doubtless obtain a duty of from 40,000,000 to 50,000,000.

But such a test would be difficult to make satisfactorily; and besides would be of no practical value to pump users.

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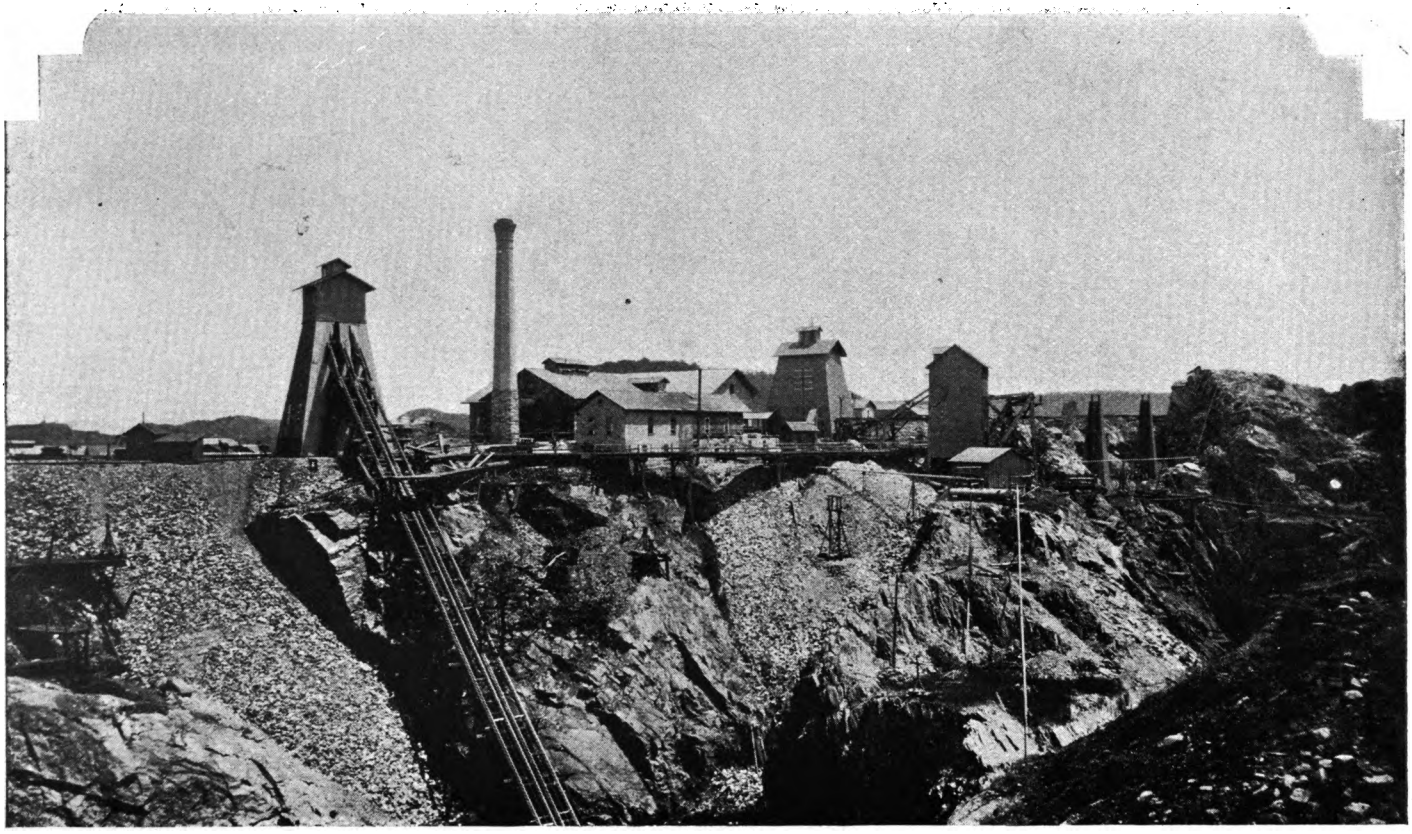

A VIEW AT LAKE SUPERIOR HARD ORE MINE.

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THE MARQUETTE IRON RANGE OF MICHIGAN.*

BY GEORGE A. NEWETT.

By permission of Dr. L. L. Hubbard, State Geologist of Michigan, the accompanying map of the Marquette iron district has been copied, with a slight reduction of scale, from a map of the Upper Peninsula of Michigan in the possession of the Michigan Geological Survey.

THE MARQUETTE DISTRICT.

Briefly, it posesses a length of forty miles and has a width of from three to ten miles. Its eastern terminus is near the city of Marquette, and its western a few miles south of the village of L'Anse. The formation trends nearly east and west. The iron ores occur in the Huronian rocks of this area, of which there are some thirty members. This series of rocks has been subjected to an enormous lateral pressure in line with its axis, causing foldings of the strata, tilting them sharply upwards from their original position. Through this, eruptive rocks have forced their way. In these folds of the formation the ore is found generally in lenticular-shaped masses or "pockets," as they are locally termed. The formations are very much distorted and twisted in many places so that following of ore veins is not easy of accomplishment, in this respect being much more difficult than upon any of the other ore ranges of the Lake Superior region. The eruptive rocks have played an important part in assisting in the concentration of the ores as well as protecting the latter at the time of the terrific glacial grinding to which this country was subjected.

While the first discovery of ore was made in the Marquette district as early as the year 1846, it was not until 1856 that

* This paper was prepared originally as a guide for the Fourth Annual Meeting.

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shipments of ore were credited to it, there being no means of transportation until the latter-mentioned year. Naturally, the work of development was tedious and expensive. Little was known of the business of mining. The methods were faulty, the machinery primitive, and the first million of tons was not produced in a single season until 1877. This achievement was not referred to without some feeling of apprehension on the part of the mining companies, however. I well remember the sober predictions that such an enormous quantity of ore must surely flood the market to the exclusion of other stocks for some time to come. And at this period in its history Lake Superior boasted no other ore range than this. Since then the gain has been steady, and the close of 1895 finds a credit of 43,937,510 gross tons for this range.

It possesses both hard and soft ores, bessemers and non-bessemers (all that the makers of iron and steel need to give them satisfactory mixtures), and it has the means at hand to produce them rapidly. The distance to lake port is fifteen miles from the most active scene of mining operations, Marquette being the nearest lake shipping point, while Escanaba is sixty miles away, but with a lake rate for the handling of ore that brings the freighting charge, rail and lake combined, to about the same figure for deliveries at Lake Erie ports.

The total number of tons sent out in 1895 was 2,095,166, this being a gain over the previous year of 36,843 tons. This would have been considerably increased but for a strike of miners and mine laborers, lasting for ten weeks, in the midst of the shipping season.

The most easterly mines of the range now in operation are those in and surrounding the city of Negaunee, a bright town with a population of over six thousand.

THE BUFFALO MINING COMPANY.

Under the above title are now operated the Queen, Prince of Wales, Buffalo and South Buffalo mines. They are all located on section 5, town 47, range 26. The ore deposits occupy

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troughs made by the folding of the slates. On the south forties there is a fold that holds what is termed the "Regent" lens, this being on the Queen tract. The Queen mine old lens occupies another fold in the same forties farther north, and in the next fold is the Prince of Wales and the Buffalo vein. The ore made up to the overlaying sand and was first secured at the Buffalo old mines in open cuts, but they have mined out these, and all the ore is now taken from underground, the caving plan being observed.

The Regent deposit has been worked to the fourth level, 250 feet from surface. A two-skip inclined shaft takes care of the ore.

The Queen has a vertical depth of 450 feet. The Prince of Wales has similar depth.

The mines of the company have produced 2,053,705 gross tons of ore. The fee is owned by the Breitung estate, W. P. Healey and others. The principal owners of the lease are Corrigan & McKinney, Cleveland, Ohio. The general manager is T. F. Cole, Negaunee. Richard Roberts is mining captain.

THE NEGAUNEE MINE.

This property lies north of the Buffalo group of mines, being located on the northwest quarter of section 5, and for some years has been an important producer of high-grade bessemer ore. The latter is of a schistose nature, is so firmly in place that it all has to be drilled and blasted, and in the upper levels very large stopes were mined without the use of timber. The vein is a flat one, having a dip to the northwest of 34 degrees on its upper side, and of 31½ degrees on its lower.

The mine has but one shaft, this being in the hanging in the upper levels, and has been continued to the 486-foot level, which is the third in the lower portion. It is vertical, having skip-way and ladder-way. The three levels reached by this shaft have been worked out. From the third level a shaft was put down on the foot wall, but the inclination of 35 degrees being more upright than the dip of the vein, the shaft is now into the foot wall, cross-cuts being necessary to connect with

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the ore of the different levels. Of the latter there are six, upon the upper four of which the principal mining is now being done. Capt. Samuel Mitchell is agent; Alfred Newcombe, mining captain.

The total tonnage produced at the end of 1895 was 648,338.

THE GRAND RAPIDS.

This mine is located in the southern part of the city of Negaunee occupying ground considerably elevated above the town. Its ores are found in the western extension of the formation of the old Milwaukee mine, now idle on account of exhaustion of the lenses which gave the product in the past. The diorite rises on both sides of the trend of the formation, which is east and west, and in the jaspers and soapstones the ore lenses are found. They have two shafts in the foot-wall, these being down to the 450-foot level, and have a length of 450 feet measured on the incline, of about 65 degrees. The fee is principally owned by the Breitung estate. The mine is now idle. Its total production is 110,599 tons.

THE BARASA.

This property lies directly east of the Negaunee mine tract, and adjoins the latter. Ore of excellent quality was cut by diamond drill borings, and they attempted to reach it with a shaft through quicksand. After many months and many thousands of dollars expended in the effort, it was finally abandoned without the sought-for ledge being encountered. The owners now talk of trying a shaft in the solid rock that outcrops a short distance north of the old shaft.

THE JACKSON MINE.

This property is attractive in the history of the iron ore region of Michigan and the entire Lake Superior region, because of the fact that it was here the first discovery of ore was made, here the first mining was done, and from its ore the first iron was manufactured. The discovery of the ore was made in the winter of 1845-6, the glistening mineral being first

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seen where the upturned roots of a tree exposed it to view. Since that time the mine has been an active producer, and the fact that it is still one gives some idea of the persistence of the ore deposits of this range.

The older workings of the mine extended well towards the main street of the business portion of Neguanee city, but this territory has been abandoned and operations are now being conducted on the western end of the company's property, half a mile farther west, where one shift is worked and where the monthly product amounts to about 4,000 tons. Both hard and soft ores are found, these occurring indiscriminately in the vein. The total product is 3,380,691 tons. Capt. Samuel Mitchell is president and manager, Jas. Harvey, mining captain, C. B. Mason mining engineer.

THE BLUE MINE

lies next west of the Buffalo group. It is to the 526-foot level, and is now idle, 83,280 tons having been sent out. Samuel Mitchell has charge.

THE CAMBRIA MINE.

The location of this is about a mile north and west from the business portion of the city of Negaunee. It lies close to the south shore of Teal lake, and is worked under lease from the Teal Lake Iron Company. Work was begun here in 1876 on lenses of ore that outcropped on surface, and from which a considerable product was secured in open pits.

Two lenses of ore are found to the north of the old pits, these having about 300 feet of ground between them, and to each a shaft has been sunk. No. 2 shaft is the most easterly, and is down to the eighth level, 570 feet, and 60 feet more has been sunk for the addition of another level. No. 3 shaft is located 400 feet northwest of No. 2, and both are connected by a drift at the 6th level.

In winning the ore they use the ordinary square sets, taking rooms two sets wide and leaving three sets of ground to support the hanging. The pillars are secured by caving them.

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The best ore is found in the east end of the mine, where it is of bessemer quality, giving about 64 per cent in iron.

The mine is well equipped with machinery, having four six-foot hoisting drums, and gives promise of being an important producer for many years to come. It has yielded a grand total of 751,260 tons, of which 39,467 tons were shipped in 1895.

A. W. Maitland is general manager, John Deacon mining captain, B. La Londe mining engineer.

THE LILLIE MINE

adjoins the Cambria immediately upon the west, and is operated by the Cambria Mining Company. The ore occurs in the same fold in which the original workings of the Cambria mine were made, but it is of different character, being very soft, and is also non-bessemer. They have two shafts, one to the 300-foot level, which is used only for ventilation, and one to the sixth level. The latter is vertical to a depth of 350 feet, and then follows the inclination of the foot, 51 degrees, for 400 feet, measuring on the incline. They talk of sinking another shaft several hundred feet southeast from the present main one, but the work has not been commenced as yet.

The ore is won by slicing from the top, letting the overlying drift and rock follow down. This is observed throughout all parts of the mine with the exception of a portion of the east end, where the capping is very strong, and here the ordinary square sets are employed.

The mine has yielded 420,946 tons and is under the same management as the Cambria.

THE HARTFORD MINE

is located next east of the Cambria, and is now idle. It has two shafts, the deeper of which is 450 feet on its incline. Mr. Ben Neeley, of Negaunee, the president and manager, informs me that they have 60 feet of ore of good quality.

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MINES OF PALMER.

The village of Palmer is the commercial center for the mines of the Cascade range. It is five miles south of the city of Negaunee, and the vicinity has been the scene of great activity in former years, but during more recent ones it has felt the depression like other towns depending on their iron mines for business. While much has been done in the past in the way of exploration, but few mines have been developed. Just now there is a demand for iron ores high in silica and low in phosphorus, and the Cascade range possesses those of this nature, and they are being developed. Prominent among these are the mines of

THE CONSOLIDATED MINING COMPANY.

These were formerly known as the Mesabi's Friend mine and the Richards' mine. The first was located on the south half of southeast quarter of section 28, town 47, range 26, the latter on the northwest quarter of northwest quarter of section 33, and were leased for a term of twenty years, the royalty being ten cents per ton for ore yielding under 58 per cent in iron, and fifteen cents for ores that gave a higher percentage than 58. The company also owns the fee of the southeast quarter of section 26, same town and range as properties above described. The leases are secured from A. H. Wick, of the Home Iron Mining Company, Cleveland, Ohio.

From the first described of the above there were mined and shipped 5,503 tons of high silicon ore during 1895, the product coming from an open cut, from which it was cheaply secured. The ore assays 48.30 per cent in iron .026 per cent in phosphorus, 28.80 per cent in silica.

THE PRIMROSE VALLEY

lies west of the Consolidated. Work was begun here in February last. There is an immense outcropping of ore similar in quality to that of its neighbor that can be readily secured. A trial lot is being sent out. William Polkinghorn has charge.

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THE PLATT MINE,

located on the northwest quarter of the southeast quarter of section 29, 47, 26, is idle, having shut down the present summer.

THE STARWEST MINE

is better known as the Wheat, under which title it was operated for many years. Its location is the southeast quarter of the southeast quarter of section 29, 47, 26, the fee being owned by the Home Iron Mining and Manufacturing Company, Cleveland, Ohio. There are two ore formations here with diorite separating them, and two shafts reach the deposits. These have lately been repaired and placed in condition for active operations underground. Additions and improvements have been made to the plant of machinery, and a reorganization of the old company has taken place, Mr. Hoar's interest having been purchased by prominent people of Marquette county. The officers are: S. R. Kaufman, president and treasurer; T. F. Cole, vice-president and general manager; L. G. Kaufman, secretary; Harry Whitburn, mining captain.

THE VOLUNTEER MINE.

This is the most important mine on the Cascade range, and is located in the village of Palmer. It was for many years known as the Palmer mine, and has sent to market 1,001,955 tons of ore. It was closed down in the spring of 1894, due to the feeble market and the prejudice against hard ores, of which it is a producer. In 1894 it shipped 26,946 tons and in 1895 sent out 32,672 tons, and has something like 400,000 tons now on hand at the mine.

The Volunteer is rich in large bodies of ore, but the quality is not up to the standard of hard ores now demanded by makers of iron and steel, and the price offered is not sufficient to pay for working the property, so the latter is full of water. The principal work done for two years before the closure was at the east end of the mine in A, B, and C shafts. The former is the most eastern and is down to the sixth level. B is 300

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feet farther west and is to the tenth level. There has been but little work done below the fifth, and the showing of ore was a magnificent one.

The ore at B shaft gives about 55 per cent in metallic iron and is wavering on of the bessemer limit as to its phosphorus content. C shaft ore gives 62 per cent. iron.

There is a fine equipment of machinery, and everything is in shape for active mining whenever the order for resumption comes. The company possesses the fee of 1,800 acres in the immediate vicinity.

Alfred Kidder, Marquette, is agent; Thomas Walters, Ishpeming, superintendent; Mark Elliot, Palmer, cashier.

MINES OF ISHPEMING CITY.

Ishpeming is the mining center of the Marquette district. It is a town of over 12,000 inhabitants who are wholly supported by the mines. It is two miles west of Negaunee, and fifteen from the lake port of Marquette. Its mining corporations are powerful ones, possessing the fees of their vast estates; they have ample capital to carry on their affairs, and have been remarkably successful.

THE LAKE SUPERIOR IRON COMPANY

was the second to engage in iron mining in Ishpeming, and the third in chronological order in the Lake Superior district, its first shipment of ore having been made in 1858. It has also credit for having produced more ore than any other iron mine in the district, its shipments up to the present reaching the magnificent total of 6,834,472 gross tons, of which 342,097 tons were marketed in 1895. It has been in constant operation in all seasons day and night. It has paid its labor promptly, has been progressive and energetic, and has done much in calling attention of capital to this mineral field.

Due to so long a period as has marked the operations of the company, there are many changes from the conditions that marked their earlier history. In the early days the hard ores were the ones sought, but little being known of the softer,

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and these were mined from immense open pits that still mar the surface in many places. The hard ores outcropped on the north side of a high range of diorite hills that trend east and west through the city, and on this side of the hills the work of the company was confined for many years. Extending eastward there is a change from the hard to the soft ores, and a break in the hills makes the valley or basin in which Lake Angeline formerly lay. The waters of this lake, 800,000,000 gallons, have been pumped out, and underneath the old lake bottom the Lake Superior, Cleveland, and Pittsburg & Lake Angeline Companies are now all conducting mining operations.

The ores of the Ishpeming mines occur in troughs made by the folding of the diorite, the latter being in line with the trend of the immense synclinal, east and west. On the north fold there are the hard ore mines of the Cleveland-Cliffs Company; in the next going south are the hard ores of the old Barnum and Lake Superior, and the soft ores of the Lake Superior; next south the soft ores of the Lake Angeline and the Section 16 mines of the Lake Superior Company are held. In these folds are the usual quartzites, jaspelities, soapstones, paint rock, and other associates of the ores common to this field.

The Lake Superior operates the Lake Shaft, Old Mine Hard Ore, Section 16 Mine, and Section 21 Mine.

THE OLD MINE HARD ORE

is located at the west end of the high range of diorite to which I have referred. Its lowest level is 920 feet from surface, this being at the most westerly shaft, No. 7. No. 6 is the most easterly shaft on the hard ore deposits, and is down 840 feet. These ores are of slate variety, running high in iron and containing no moisture.

They secure the ore here by mining from the bottom upward, filling with waste rock that is readily milled down. There is a great tonnage of ore still remaining in pillars that will give a substantial product for many years to come, as pillars are plentiful throughout this portion of the mine.

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THE LAKE SHAFT.

This shaft was sunk to find the eastern extension of the bodies of hematite that were encountered further west, and which have been worked out in what used to be known as the "Old Mine Hematite." It is vertical and is down to the 750-foot level, but up to the present the 513-foot is the lowest level upon which mining has been done, six levels having been opened up to and including this.

What promises to be one of the most important mines of the Lake Superior Iron Company is now being given attention. The location is 800 feet south of the Lake Shaft. Here they explored with the diamond drill in the summer and fall of 1895, and five holes encountered soft blue hematite of excellent quality, it having a thickness of from 50 to 100 feet. Assays give from 56 to 68 per cent iron, and show well under the bessemer limit as to phosphorus. To reach this ore they ran a drift from the 300-foot level of their Lake Shaft, to a point under the bottom of the deposit, and then rose into it, and are now rising to the top with the intention of working on the caving plan. The surface here is composed of 15 feet of mud and 53 feet of sand, gravel and hardpan. The ore from the new deposit will be taken through this to the Lake Shaft, power of some kind being used to do the tramming.

SECTION 16 MINE.

This property of the Lake Superior Iron Company adjoins that of the hard ore workings at the west end of the Lake Angeline mine, and it has been a producer of hard ore for several years past. It was prospected from a small shaft put down near the Lake Angeline mine, and since then two others have been sunk to the northwest. Of these what is known as the "New Shaft" is the principal working one. It is down to the 630-foot level, but the two lower levels are not opened out as yet.

Two miles south of the city of Ishpeming is the Lake Superior Iron Company's

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SECTION 21 MINE,

which adjoins the workings of the old Winthrop and Mitchell mines on the north and west. This is a conparatively new mine, and they have not produced much from it as yet, the work thus far performed being confined to the sinking of shafts, opening of levels, and preparing the property for active production.

There are three shafts to the ore body.

This promises to be an important addition to the mines of the company. Indeed, it is that already. They are finely equipped with modern hoisting, compressing and pumping machinery. Capt. John Trebilcock is in charge of the underground work and has general supervision over the surface as well. Jas. Trebilcock is mining captain at the Hematite and Section 21 mines of the company, while John McEncroe performs similar duty at the old hard ore mines.

C. H. Hall is agent; W. H. Johnston, superintendent; Jas. McCutcheon, assistant; Jas. Clancy, master mechanic; C. E. Hendrick, mining engineer.

THE PITTSBURG & LAKE ANGELINE IRON COMPANY

is one that enjoys a national reputation, this being brought about by the fine quality of its ores and the magnificent dividends it has paid. For many years it was feebly worked, its earlier history not being marked by any of the activity that has appeared during the past ten seasons. Their large deposits of ore were known in the early days, when operations were confined to an open pit on the north side of the big diorite hill that rises abruptly a few hundred feet south of the old Lake Angeline bottom. The first discoveries of importance were to the west of this open pit, and here, up to within the past three years, operations have been solely concentrated in what they now call the "old mine." Work here is largely confined to the robbing of pillars. Both hard and soft ores are found.

The East End mine, a comparatively new one, is three-fourths of a mile east of the old workings. They work on the

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caving, North of England system, taking the ore of one level at a time. Power for tramming is provided by electricity. The eight-hour day was first adopted here and is now general in the city. Thomas Walters, superintendent; E. F. Bradt, mining engineer.

The total product is 3,352,561 tons.

THE CLEVELAND-CLIFFS COMPANY'S MINES.

The different properties of the Cleveland Iron Mining Company and the Iron Cliffs Company are now operated under the title of Cleveland-Cliffs Company. This is a powerful corporation possessing about 50,000 acres of land in the mineral territory of this district. They are an enterprising concern, employing a large number of people, and have done much to assist in the development and success of the district. Their prominent mines are the Cleveland Hard Ore, Cleveland Lake Shaft, Cleveland Angeline, Cleveland Hematite, Salisbury, Foster and Cliffs Shaft.

THE CLEVELAND LAKE MINE.

Under the old Lake Angeline bottom, and near the huge diorite bluff that rises from the north side of the lake basin, is located the Cleveland Lake mine. Its ore was discovered with a diamond drill a dozen years ago. Since then the lake has been pumped out, and the company has not engaged in rooming ore to any great extent because of the fact that lying above the ore is from 15 to 40 feet of mud, this having the consistency of cream. The ore does not lie next this mud, there being sand and gravel between in places, and at certain points there is a capping of rock separating the two, but the intervening material is not sufficiently substantial to warrant them in thinking it would remain to protect the levels from the mud in case the ore were mined in the usual manner. The mud has delayed them greatly, and they have been forced to move slowly that the mine might be properly insured against accident. At present they are successfully caving the surface. There are three levels.

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THE CLEVELAND ANGELINE

mine is located on the south side of the old lake basin, and is a continuation of the deposit of the East End mine of the Pittsburg & Lake Angeline Company, the ore partaking of all the excellence of that of its renowned neighbor. This occurs in a fold of the diorite to the south of the one containing the Cleveland Lake Shaft ore, and to reach it they have put in a drift 635 feet long from the second level of the Lake Shaft mine, this being all in diorite.

The shipments of ore from this mine for the season of 1895 yielded 67.25 per cent metallic iron and .025 per cent phosphorus. It is soft, blue hematite, similar in appearance to the ore of the Lake Angeline Company.

The electric motor has proved a valuable addition at these properties. Due to the long distances they have to tram the ore, some other power than the old-fashioned hand pushing was necessary. From the east end of their Angeline deposit to the main shaft the distance is 2,160 feet; from the northwest end of the main mine, on the first level, to shaft is 850 feet, and from the open pit and around it to the main shafts, 1,425 feet .Two motors are used, one of thirty and one of sixty horse-power. The electric generator is 4-pole, 100 kilowatt, 220-volt, making 600 revolutions per minute, and driven by a 16 x 24-inch Corliss engine with separate wrist plates and excentrics for admission and exhaust valves. Ten 3½-ton cars can be handled in a train. Cars are bottom-dumpers, and are automatically locked by passing over a roller placed between the rails of the track after the load has been discharged.

As there has been considerable interest shown in power tramming apparatus of late, I have secured the following figures from the books of the company, showing the cost per ton of ore of operating the motors:

Engine house expense, motormen and brakeman	$.0201
Men running underground pockets and chutes.	.0185
Small amount hand-tramming and tending skips.	.0128
Total cost per ton.	$.0514

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The test was based on a monthly product of 41,604 tons. The motor capacity is 60,000 tons per month for the two.

THE CLEVELAND HARD ORE MINES

are located in the eastern part of Ishpeming city. These are idle with the exception of the "Sawmill" pit, where 1,000 tons per month are secured from the roof and pillars. This ore is of fine quality, giving 68 per cent iron and .030 per cent in phosphorus. It is a specular slate, and is regretted there is not more of it.

THE SALISBURY MINE

is south of the Pittsburg & Lake Angeline mine, and separated from it by a diorite ridge that rises to a height of 240 feet above the level of the ground about the collar of the shaft. Work was first started here in 1872, and an open pit provided the product for several seasons, after which the mine was worked as an underground one. They have attained a depth of 759 feet, to the sixteenth level.

THE CLIFFS SHAFTS.

This mine lies to the north of the Lake Superior hard ore old mine, is in a fold of the diorite to the north of the Superior hard ore fold. The property has been idle since the summer of 1894, having at that time a large stock of ore that the company could not dispose of at a living price. Considerable has since been shipped, but there is now in stock at the mine 150,000 tons. A crushing plant was added in 1894, due to demands made by furnacemen.

Reaching the ore are two magnificent vertical shafts that are to the lowest level, 511 feet. The first level, called "C," is 313 feet from the surface, and the sixth is the lowest. No timbering is used, the walls being so firm that none is needed.

There are fine stopes of ore in the mine. Indeed, the property is just fairly developed for mining, and a product of 250,000 tons annually could be secured for many years to come. There is everything at hand to operate the mine when it re-

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sumes. The machinery is first class, there are fine stone engine and boiler houses and shops, and nothing is lacking.

THE FOSTER MINE

is being equipped throughout. It produces an ore well suited to the manufacturer of malleable iron.

The mines of the Cleveland-Cliffs Company have produced 8,971,288 tons.

W. G. Mather is president, Cleveland, Ohio; F. P. Mills, who had been agent for many years and thoroughly competent, resigned in January, 1896, and his place has not yet been filled; A. J. Yungbluth is auditor; J. E. Jopling, mining engineer; J. M. Vickers, master mechanic. Thomas Buzzo is mining captain at the Cleveland Lake mine, A. E. Buzzo at the Salisbury mine.

THE WINTHROP MINE

is two miles south of Ishpeming city. The underground levels of the old mine have given all they possessed in the way of ore, and operations are now confined to the taking of a low grade material found in the upper portions of the ore measure. They are securing this by open-pit mining, and have a large stoping face, about 100 feet high, from the bottom of the level up to the surface sand. Several hundred feet south is their No. 2 mine, underground, and still further south is another lean ore outcropping known as No. 3.

F. Braastad, Ishpeming, is manager and vice-president.

THE DEXTER MINE

is six miles west of Ishpeming, on section 3, 47, 28. It is a small mine from which an annual product of from 7,000 to 21,000 tons is secured.

There is one shaft 500 feet deep. Ore is manganiferous and finds ready sale. Jacob Harper is mining captain; G. R. Persons, cashier.

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THE REPUBLIC MINE

is located at Republic, Mich., and gives support to the bright little town of 3,000 souls. It has been one of prominent mining properties in this iron ore producing district and has enjoyed a world-wide reputation by reason of the purity of its product, it being of the finest found anywhere.

Originally the workings of the mine were three-fourths of a mile from the present scene of activity, and in an immense bowl-shaped basin to the lowest point of which the ore dipped, and in which direction the shafts were inclined. The foot is a high range of jasper that rises above the surrounding level to a height of 150 feet, and it is in a belt of this that the ore occurs, being lenticular-shaped masses of varying size. Near the surface they were of immense proportions, but as the bottom of the basin was neared they kept pinching up and growing smaller, until all of the old pits at the west end of the curve were abandoned. On the northern swing of the curve there is a change in the direction of the trend of the formation, it making nearly north and south, and it is on this north and south line that new and important discoveries have been made. Near the point at which the formation turns northward at the north side of the basin, is located No. 8 shaft, a one-compartment vertical, down to the 1153-foot level. This and No. 1 shaft, a short distance to the southeast, have been the principal ones for several years past.

They are sinking a fine new three-compartment shaft on the line of the strike of this ore, and 1,200 feet north of No. 8 shaft. It is in the jasper foot, and will have two skip-ways and a cage-way, its inside measurement being 6 x 18 feet. It has reached a depth of 100 feet. The collar of this shaft is 42 feet above the railway tracks so that ample facilities for ore crushers will be had in case the company decides upon their use. With this shaft down 200 feet they will put in a cross-cut from it, as they have hopes of striking ore that was found with a diamond drill in the summer of 1895.

At No. 1 shaft is a stope 180 feet high that gives ore yielding 68 per cent iron and .020 phosphorus.

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In times of high water in the Michigamme river there is enough air generated at the company's hydraulic works to supply power for all the machinery at the mine, but in stages of low water they have only enough to operate one-half their plant, and air compressors of the mine are run by steam to provide this. Power for the new shaft will be transmitted from No. 5 engine house, where there are four 12-foot drums. Nos. 1 and 8 shafts are operated from this station.

A Cornish "lift" at No. 8 shaft takes care of all the water the mine makes, it running about nine hours in the twenty-four. This plunger is down to the 911-foot level, and will be extended to the bottom of the mine this year.

The Republic has shipped, all told, 4,251,026 gross tons of ore, and its product for '95 was the greatest since 1891.

David Morgan is agent; Peter W. Pascoe, mining captain.

THE CHAMPION MINE.

This property is located thirty miles west of Marquette, on lines of the Duluth, South Shore & Atlantic, Chicago & Northwestern and Chicago, Milwaukee & St. Paul. There is a town of 2,000 inhabitants named after the mine. The ores here found are hard slate, specular and magnetic hematites, that are of fine quality, the entire product being of bessemer grade, although several classes are made that contain different percentages of iron. The first shipments were made in 1868 and there have been sent out since that time about 3,000,000 tons.

The property was closed during '93 and '94, and resumed in the spring of '95, when work was confined to the eastern end of the mine and consisted in robbing the old pillars. In September of '95 the task of unwatering the underground workings at the west end of the mine was begun, which has now been completed, and they are again doing regular mining and development work.

The Champion has been opened on the trend of its ore formation for a distance of 2,500 feet and has, going from east to west, shafts C, 1, 2, B, 3, 4, 5, 6, and 7. Of these Nos. 1 and 6 are in the footwall, the others in the ore measure, they having

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been located long before the present management took hold. They have two "runs" or lenses of ore, the pitch being to the west at an inclination of 60 degrees. The hanging is a compact quartzite, the foot a jaspelite underlain with diorite. The walls are very substantial, timbering being seldom needed, and the closeness of the walls prevents the water finding a way into the mine, so that but little pumping has to be done. With the resumption of operations, recently, the mine was unwatered by the use of bailers holding 1,200 gallons, these lifting 300 gallons per minute.

They carry levels 60 feet thick, leave floors of 15 feet, carrying stopes 45 feet. They go to the top of the stope putting in a drift, and from this they underhand stope in the usual way. The contracts to miners is so much per foot of ground drilled. The company has foremen who superintend the placing of holes. The contracts also call for the blasting of the holes. It is simply a question of drilling with the miner, and he hastens to get as many feet as possible. Power drills are used. The tram cars are large ones, holding four tons each. They are mounted upon short tracks and the body of the car is turned on a pivot to face the stope, the hopper being made low on one side to permit of easier loading and inspection. The ore is all inspected and the rock taken out underground.

The Champion, like other hard ore producers, has been forced to add crushers to its plant to reduce the ore to the size demanded by furnacemen. It has a new plant, consisting of three 55-ton crushers placed side by side. These are of the Blake pattern, with openings 24x24 inches. They are run by manilla rope transmission by a pair of Corliss engines, ropes running over 10-foot pulleys. The ore from the different shafts is run to the crushers by gravity, and thence to the stockpiles or cars, it being the object to minimize the cost of treatment. The company has no royalty to pay, which is a point in their favor.

There is a magnificent equipment of machinery, four 14-foot drums, 7-foot face, a compressing plant with 30 x 48-inch air and 28 x 48-inch steam cylinders.

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SUSPENDED MINES.

Near Champion are several producers of low grade soft ores that are idle.

At Humboldt, a few miles east, are the Humboldt and Foxdale mines, hard ore producers, that could not earn a profit under conditions met with the past few years. The Bessie, also near the latter place, is idle. It lacks a railway.

At Michigamme, still further west of Champion a few miles, is the Michigamme mine, a hard ore, that is idle, and in the near vicinity are several properties that contain large amounts of limonite ore that is too poor to stand transportation charges to Lake Erie ports. These ores generally smelt freely, and are excellent for foundry purposes, but until they can be converted into iron at home there is little likelihood of their being worked.

There are several prospects a few miles from Republic that have given considerable attention in the past, but the quality is not right for their resumption. They are hard ores and generally much mixed with quartz.

THE SWANZY.

This mine is the property of the Escanaba River Land and Iron Company. Its location is apart from the range on which the principal mines of the Marquette district are found, being in town 45, range 25. The owners have the fee of about 700 acres containing this and other promising prospects in the immediate vicinity. It is reached by a branch track of the Chicago & Northwestern Railway from Swanzy Junction, 18 miles south of Negaunee.

Considerable work was done during the past three years, but operations were suspended in the summer of 1895, due to the lack of sufficient funds on the part of the company to properly open it up. There is a fine body of soft ore here and considerable of this proves by analyses to be of bessemer grade.

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SHIPMENTS OF ORE.

Table showing shipments of iron ore from the Marquette range for season of 1895, and total tonnage shipped for all years:

GOLD.

The Ropes gold mine, the only one in the state of Michigan, continues in operation. It has produced $605,056.95 worth of gold and silver, of which amount $548,973.40 has been gold. The mine has a vertical depth of 850 feet and is well equipped with machinery. W. H. Rood, Ishpeming, is manager.

MARQUETTE.

This is one of the prominent ore-shipping ports, and takes care of the larger portion of the business from the Marquette range, the distance from the center of the district to port being 15 miles. The Duluth, South Shore & Atlantic Railway, one of the best equipped in the region, has three docks at Marquette, these containing 700 pockets with a capacity of 100 tons per pocket.

They have 1,200 25-ton ore cars and 2,000 four-wheeled 7-ton cars. They use in the shipping season fifteen switch engines and twelve road engines. Owing to the nearness of the mines to lake port, this company gets a much better result per engine and car than others where the distance is considerably greater.

Besides their main line, the D., S. S. & A. Ry. has something over fifty miles of side tracks used exclusively for the iron ore traffic. They have two lines of track running between Ishpeming and Marquette, and the value of the property used in ore transportation exclusively, this embracing the docks, is estimated at four millions of dollars.

The tonnage of iron ore sent from Marquette in 1895 was 1,075,374.

A second ore line is just now completed between Ishpeming and Marquette by the Lake Superior & Ishpeming Railway Company, the latter being made up of capitalists who are

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prominent in the Cleveland-Cliffs and Pittsburg & Lake Angeline Iron Companies. This line is now doing business. An ore dock, 1,200 feet long, has a capacity of 30,000 tons, 100 pockets holding 300 tons each. The equipment of rolling stock consists of 11 locomotives and 400 30-ton ore cars. Taking the lead of all ports is that of

ESCANABA.

where the Chicago & Northwestern Railway owns and operates the docks, which are five in number. The capacity of these is as follows:

Dock No. 1, 24,104 gross tons; No. 2, 20,928 tons; No. 3, 30,284 tons; No. 4, 32,750 tons; No. 5, 43,152 tons, giving a total capacity of 151,218 tons. To this port the entire product of the Menominee range is sent, excepting the small percentage that may go out by all-rail; a considerable amount of ore is secured from the Marquette range, and some from the Gogebic. The quantity contributed from each of these ranges for the past season was as follows: From Menominee, 1,867,281 tons; from Marquette, 850,665; from Gogebic, 144,934; total, 2,095,166 tons.

The distances from the principal center of the Marquette range is 65 miles.

To the Peninsula Division of the C. & N. W. (embracing lines operating in the Marquette and Menominee ranges), are assigned 3,200 cars with a capacity of 68,000 tons. During the shipping season of 1895, 100 locomotives were used on this division.

GLADSTONE.

The amount of iron ore shipped from this port in 1895 was 109,319 tons.

There is one ore dock here having a capacity of 16,000 long tons. It is the property of the Minneapolis, Sault Ste. Marie & Atlantic Railroad, and the ore is pulled from the Menominee and Marquette ranges by the Chicago, Milwaukee & St. Paul Railway, which has an equipment of cars for the purpose.

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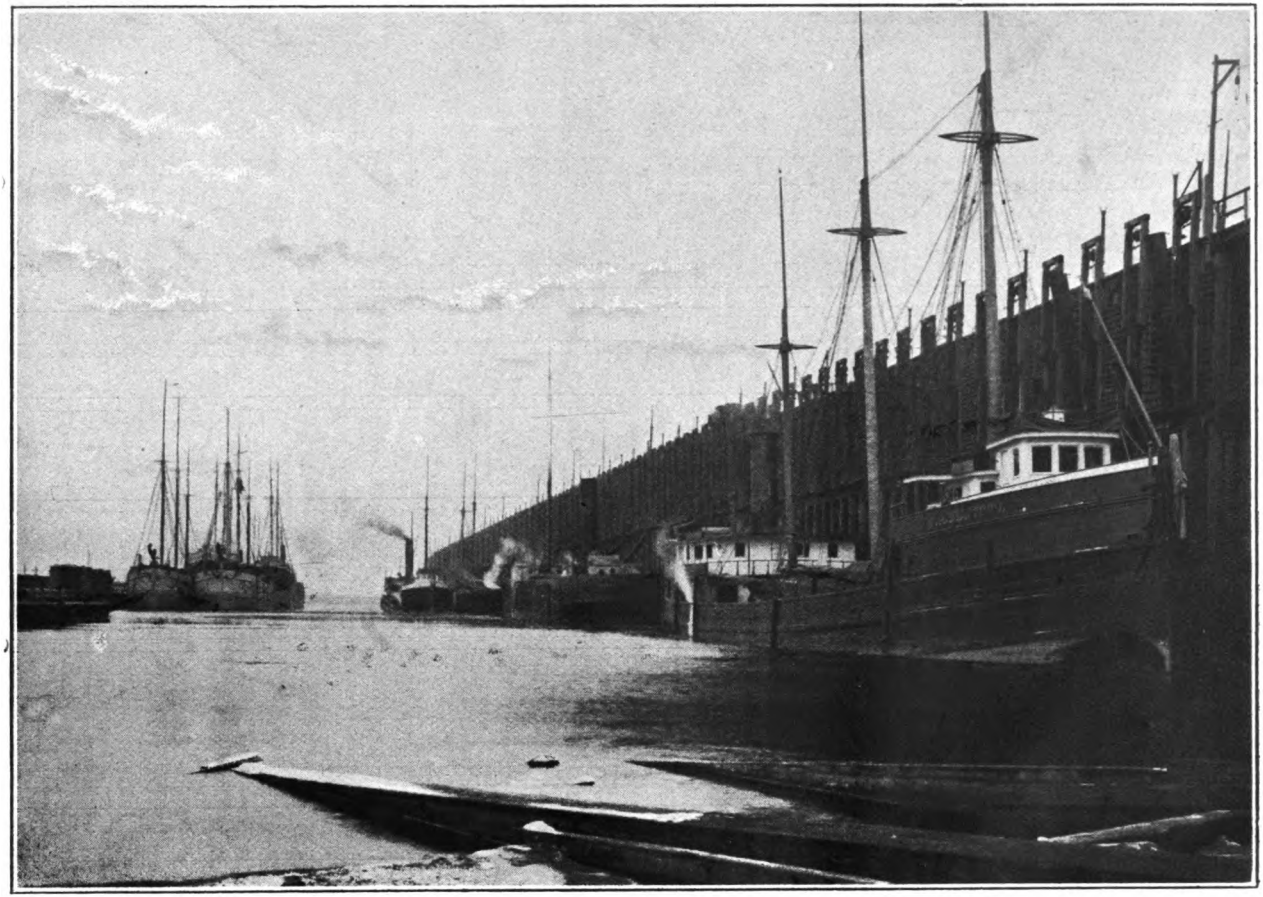

ONE SIDE OF AN ORE DOCK AT ESCANABA.

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